Coastal and Hydraulics Laboratory

ERDC/CHL TR-00-11

US Army Corps of Engineers®
Engineer Research and Development Center

Comite River Diversion Project—Diversion Channel Stage Control Structure (Lilly Bayou Structure), Comite River, Louisiana

Hydraulic Model Investigation

John E. Hite, Jr., and Joe E. Myrick

June 2000

ERDC/CHL TR-00-11
June 2000

Comite River Diversion Project—Diversion Channel Stage Control Structure (Lilly Bayou Structure), Comite River, Louisiana

Hydraulic Model Investigation

by John E. Hite, Jr., Joe E. Myrick

Coastal and Hydraulics Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Prepared for U.S. Army Engineer District, New Orleans
7400 Leake Avenue
New Orleans, LA 70118

Engineer Research and Development Center Cataloging-in-Publication Data

Hite, John E.
Comite River Diversion Project-diversion channel stage control structure (Lilly Bayou Structure) Comite River, Louisiana : hydraulic model investigation / by John E. Hite, Jr., Joe E. Myrick ; prepared for U.S. Army Engineer District, New Orleans.
78 p. : ill. ; 28 cm. — (ERDC/CHL ; TR-00-11)
Includes bibliographic references.
1. Comite River Diversion Project (La.) — Models. 2. Lilly Bayou Structure — Louisiana — Comite River — Models. 3. Hydraulic structures — Louisiana — Comite River — Models. 4. Hydraulic models. I. Myrick, Joe E. II. United States. Army. Corps of Engineers. New Orleans District. III. Engineer Research and Development Center (U.S.) IV. Coastal and Hydraulics Laboratory (U.S.) V. Title. VI. Series: ERDC/CHL TR ; 00-11.
TA7 E8 no.ERDC/CHL TR-00-11

Contents

Preface

The model investigation reported herein was authorized by the U.S. Army Engineer District, New Orleans (MVN) on 16 April 1999. The model experiments were performed during the period June 1999 to October 1999 by personnel of the Coastal and Hydraulics Laboratory of the U.S. Army Engineer Research and Development Center, ERDC (formerly the Waterways Experiment Station), under the general supervision of Dr. James R. Houston, former Director of CHL, and Dr. P. G. Combs, former Chief of the Rivers and Structures Division, CHL. These efforts consisted of testing modifications to the structure that were previously tested and reported in Hite (1994).

The experimental program was led by Mr. J. E. Myrick under the supervision of Dr. J. E. Hite, Jr., Leader, Locks and Conduits Group. Model construction was completed by the Model Construction Section, Department of Public Works (DPW), ERDC, under the supervision of Mr. Vince Durman, Chief of the Model Construction Section. The report was written by Dr. Hite and Mr. Myrick and was peer reviewed by Mr. John George.

During the course of the model study, Messrs. Don Alette, Carl Anderson, Don Jolissaint, Vann Stutts, Herb Albert, and Arthur Laurent of MVN and Messrs. John Burnworth, Allen Perry, John Trest, Bob Tucker, and Michael Weiland of U.S. Army Engineer District, Vicksburg (MVK), and Mr. Chuck Shadie of the Mississippi Valley Division (MVD) visited ERDC to observe model operation, review experiment results, and discuss model results.

At the time of publication of this report Dr. James R. Houston was Director of ERDC, and COL Robin R. Cababa, EN, was Commander.

1 Introduction

Background

The proposed Comite River Diversion Project was designed to lower flood stages along the Comite River and Amite Rivers by diverting Comite River flood flows to the Mississippi River. Previous model investigations were performed (Hite 1994)[1] to verify the diversion flows and to evaluate the hydraulic performance of the Comite River stage control structure, the diversion structure, and the diversion channel stage control structure (also referred to as the Lilly Bayou Structure). The Comite River stage control structure was eliminated as a result of the 1994 model study. The proposed diversion channel consisted of a land cut from the Comite River to existing channels of Lilly and Cooper Bayous and Profit Island Chute (Figure 1). The diversion begins on the west bank of the Comite River and runs generally west between Baker and Zachary, LA, to the head of Lilly Bayou approximately 12.9 km (8 miles).

Purpose and Scope of Model Investigation

The purpose of this model investigation was to evaluate modifications to the Lilly Bayou structure that had been made since the completion of the previous investigation. These changes consisted of:

a. The invert slope between the weir crest and stilling basin was changed from a 1V on 4.2H to a 1V on 5H.

b. The weir crest was lowered from el[2] 56.7 NGVD to el 54.7.

c. The invert of the channel upstream from the weir was lowered from el 37.1 to el 35.1.

d. The alignment of the approach walls to the weir was changed to form a rectangular section at the weir crest.

---

[1] Hite, J. E., Jr. (1994). "Comite River diversion, Comite River, Louisiana," Technical Report HL-94-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
[2] All elevations (el) cited herein are in feet referenced to the National Geodetic Vertical Datum (NGVD) (to convert feet to meters, multiply number of feet by 0.3048).

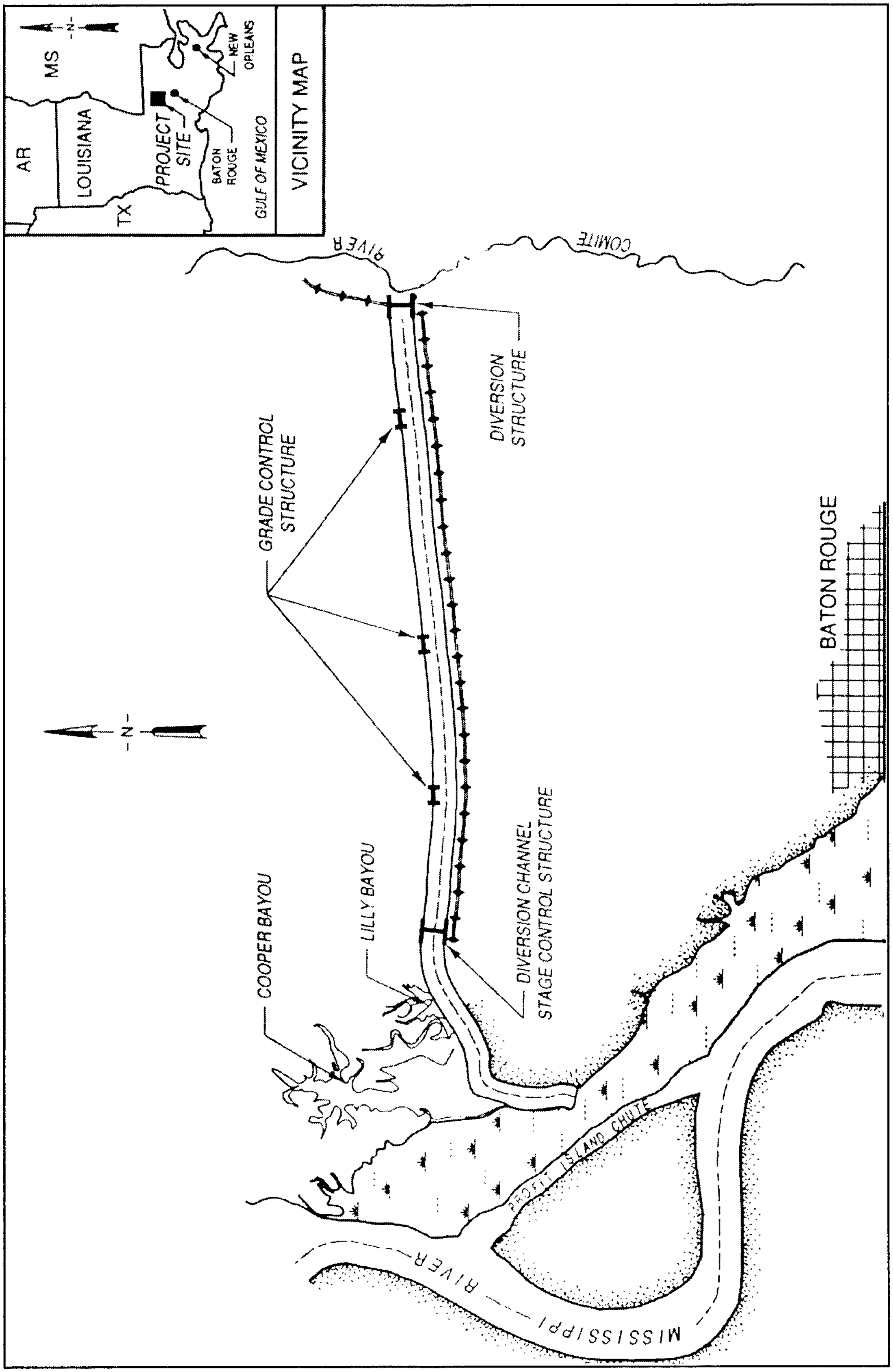


Figure 1. Vicinity and location map

e. The side slopes of the outflow channel were changed from 1V on 3.5H to 1V on 4H

As the study progressed, additional modifications were made to achieve the desired performance. These modifications consisted of:

a. The weir crest elevation was lowered from el 54.7 to el 53.0.

b. The stilling basin floor elevation was lowered from el 8.0 to el 3.0.

c. The side slopes in the approach channel were changed from 1V on 3H to 1V on 3.5 H (which did not significantly affect the performance as noted in the "Model Experiments and Results" section).

A laboratory model was considered necessary to evaluate these modifications with respect to both flow capacity and flow conditions for the range of diversion channel discharges and Mississippi River stages. In addition, modifications would be made if necessary to improve the hydraulic performance.

2 Physical Model

Description

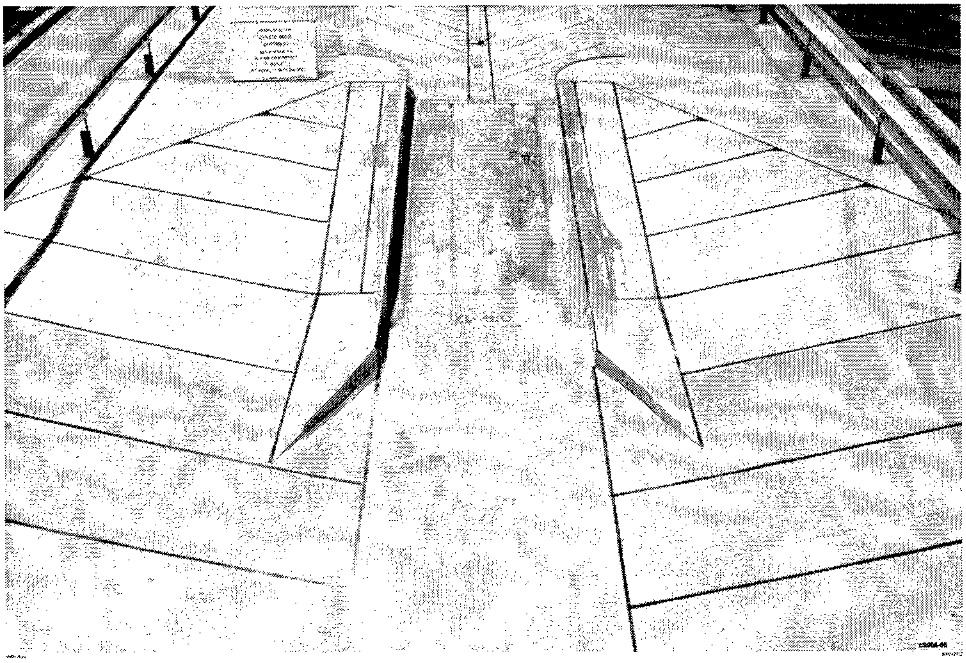
The 1:36-scale model used in the previous investigation was modified to perform these model experiments. The model reproduced approximately 112.78 m (370 ft) of the upper approach, the weir crest, spillway and stilling basin, and approximately 243.84 m (800 ft) of the outflow channel. The model was molded in sand and cement mortar to sheet metal templates. A photo of the 1:36-scale model is shown in Figure 2. A plan view of the details of the previous design model tested is provided in Plate 1. A plan view of the modified Lilly Bayou Structure is shown in Plate 2.

Appurtenances and Instrumentation

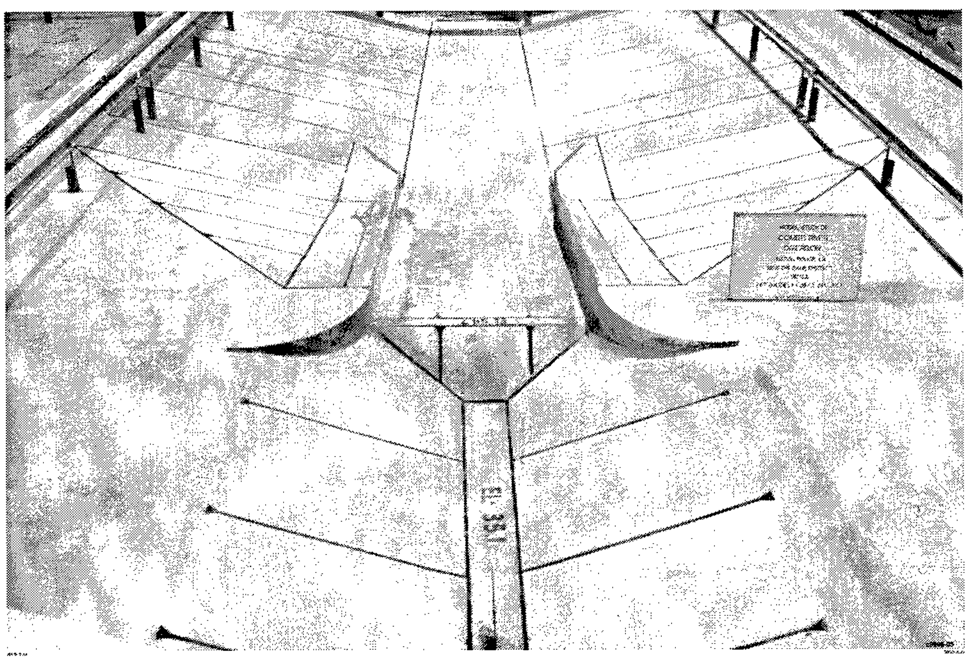
Water was supplied to the model through a circulating system. Discharges in the model were measured with venturi meters installed in the inflow lines. The flow was baffled upon entering the model to provide as uniform distribution of the flow as practical. Water-surface elevations were measured with point gauges, and velocities were measured with pitot tubes and propeller meters mounted to permit measurements at any horizontal direction and depth. The tailwater was maintained at the desired depth by means of an adjustable tailgate. Dye and confetti were used to study subsurface and surface current directions.

Kinematic Similitude Considerations

Kinematic similarity is an appropriate method of modeling free-surface flows in which the viscous stresses are negligible. Kinematic similitude requires that the ratio of inertial forces ($\rho V^2 L^2$) to gravitational forces ($\rho g L^3$) in the model are equal to those of the prototype. Here, ρ is the fluid density, V is the fluid velocity, L is a characteristic length, and g is the acceleration due to gravity. This ratio is generally expressed as the Froude number, N_F



a. Model looking upstream



b. Model looking downstream

Figure 2. Dry bed view of the 1:36-scale model of the Lilly Bayou Structure

$$N_F = \frac{V}{\sqrt{gL}}$$

where L, the characteristic length, is usually taken as the flow depth in open-channel flow.

The Froude number can be viewed in terms of the flow characteristics. Because a surface disturbance travels at celerity of a gravity wave, $(gh)^{1/2}$, where h is the flow depth, it is seen that the Froude number describes the ratio of advection speed to the gravity wave celerity.

Scale Relations

Setting the model and prototype Froude numbers equal results in the following relations between the dimensions and hydraulic quantities:

Characteristic	Dimension[1]	Scale Relation Model :Prototype
Length	$L_r = L$	1:36
Pressure	$P_r = L_r$	1:36
Area	$A_r = L_r^{2}$	1:1,296
Velocity	$V_r = L_r^{1/2}$	1:6
Discharge	$Q_r = L_r^{5/2}$	1:7,776
Time	$T_r = L_r^{1/2}$	1:6
Force	$F_r = L_r^{3}$	1:46,656
[1]Dimensions are in terms of length.		

Because of the nature of the phenomena involved in these experiments, certain model data can be accepted quantitatively, while other data are reliable only in a qualitative sense. Measurements in the model of discharges, water-surface elevations, velocities, and resistance to displacement of riprap materials can be transferred quantitatively from model to prototype using the preceding scale relations.

3 Model Experiments and Results

Stilling Basin Performance

Initial model experiments were performed to document the performance of the stilling basin with modifications *a-e* for discharges between 354.0 cu m/sec (12,500 cfs) and 945.8 cu m/sec (33,400 cfs). The varying hydraulic conditions in the stilling basin are represented schematically in Plate 3. The basin action depends on the tailwater depth (measured from the basin apron elevation) for the same discharge. Submerged flow conditions exist in the basin for high tailwaters. The stilling basin acts as a minor energy dissipator for this flow condition. An undular jump exists when Froude numbers entering the stilling basin are slightly greater than one. Plate 4 provides the hydraulic parameters pertinent to this discussion. A hydraulic jump will form in the basin when the tailwater provides a depth over the basin near d_2. As the tailwater becomes shallow, the hydraulic jump will sweep out of the basin and supercritical flow will exist in the basin.

The hydraulic conditions for downstream stage and discharge were furnished by the New Orleans District and are provided in Table 1. The tailwater rating curve coordinates shown in Table 1 are different from those in the previous model study (Hite 1994) in which curves are shown only for high Mississippi and low Mississippi River conditions. The extremes in Mississippi River stage considered in developing the tailwater rating curves for this model study ranged from el 3 (record low stage for the period of record 1980 to present) to el 52.3 (1973 Refined MR&T Project Flood Flowline). Tailwater rating curves were also developed for two downstream channel conditions, one being the existing channels between the structure and Profit Island Chute (see Figure 1) and the other representing those channels in an enlarged configuration after the projected "ultimate scour" (i.e., headcutting from el –11 at Profit Island Chute to the outflow channel invert el of 8 has occurred. This ultimate scour is projected to occur sometime within the next 50 years. Table 2 provides the corresponding pool elevation and tailwater elevation, and stilling basin action for discharges between 113.3 cu m/sec (4,000 cfs) and 945.8 cu m/sec (33,400 cfs) for the stilling basin with no baffle blocks or end sill. This information was obtained with rising stages and the same information with falling stages is provided in Table 3.

Plate 5 shows the stage data obtained for the flow conditions listed in Table 2. The dashed curve shown near the bottom of Plate 5 indicates the discharges and tailwaters when the hydraulic jump initially forms in the basin with rising stages. Since no baffle blocks were present, the jump was caused by the tailwater elevation. When the jump initially forms, it is very unstable and large standing waves were present in the outflow channel. With a slight increase in the tailwater, a stable type jump forms as indicated by the solid curve shown in Plate 5 just above the dashed curve. This stable jump curve is well above the tailwater curve shown for ultimate scour conditions and the Mississippi River stage at el 3.

Weir Rating Curve

The weir-rating curve for discharges up to the 500 –yr frequency flow (945.9 cu m/sec or 33,400 cfs) is also shown in Plate 5 (Model data). A curve, labeled computed, was provided by the New Orleans District as the desired rating curve for this weir design. The rating curve indicates the design was not as efficient as desired. For higher discharges, the stages were 2.5 – 3.0 ft higher than the computed curve. The computed curve furnished by the New Orleans District was developed by reducing the curve obtained from the earlier model investigation by 0.61 m (2 ft) to lower the stages in the diversion channel. The rating curves and tailwater stages used in the earlier model investigation are shown in Plate 6 along with the 1999 rating curve determined from the model and the tailwater stages. Since the weir crest was lowered from el 56.7 in the previous study to el 54.7 in the present model it was logical to assume the weir-rating curve would be lowered by 0.61 m (2 ft). However, modifications to the approach walls were also made which altered the weir rating. The approach flow entering the weir was improved from the previous model and is attributed to the rectangular cross section with rounded approach walls at the weir that eliminated the severe abutment contractions. Because of the reduced cross sectional area, this weir design did not pass the discharges at the desired upstream elevations (as required to prevent induced flooding along streams crossing the diversion channel and to match the previously established tailwater rating curve for the diversion structure at the Comite River). Additional lowering of the weir crest elevation below el 54.7 was required.

Stilling Basin Baffle Block Experiments

Baffle blocks were added to the stilling basin to determine the effect on stilling basin performance. The blocks were designed based on the 500 yr-discharge of 945.8 cu m/sec (33,400 cfs). The depth of flow entering the stilling basin, d_1 in Plate 4, with a discharge of 945.8 cu m/sec (33,400 cfs) was measured at 1.40m (4.6 ft). The velocity entering the stilling basin, v_1, was determined by dividing the entering depth into the unit discharge. The entering

Froude number, F_1, was computed as 4.5. Engineer Manual 1110-2-1603[1] suggests that for F_1 < than 4.6, the baffle height should be $d_2/6$. The computed d_2 was 8.26 m (27.1 ft). The baffle height was then computed as 1.37 m (4.5 ft). The EM also states that for $F_1 < 4.6$, the location of the first row of blocks should be $1.5d_2$. The second row of blocks was located 3.05 m (10.0 ft) downstream from the first row. Plate 7 shows the location and dimensions of the baffle blocks placed in the stilling basin.

The performance of the stilling basin was observed with the baffle blocks in the basin. Table 4 lists the basin performance for the 2-, 10-, 100-, and 500-yr discharges for selected tailwater conditions. For these flows, a forced jump occurred in the basin with the tailwater set for ultimate scour conditions with a Mississippi River stage at el. 3. A forced jump is defined as a hydraulic jump that occurs as a result of baffle blocks being placed in the stilling basin with a low tailwater. Without the blocks in the basin, a jump would not form and supercritical flow would be present. For the higher tailwater conditions, the stilling basin action was described as a submerged jump and performance was satisfactory. Since the stilling basin action was not acceptable for the ultimate scour conditions, additional modifications were evaluated.

Weir in the Exit Channel

The New Orleans District requested experiments to determine the height of a tailwater weir required in the exit channel to cause a stable hydraulic jump in the basin with the 500-yr discharge of 945.8 cu m/sec (33,400 cfs). The experiments were performed by stacking bricks in the exit channel 121.92 m (400.0 ft) downstream from the end of the stilling basin. A 3.05-m- (10-ft-) high weir was required to form a stable jump in the basin. Downstream from the weir, another jump formed indicating the need for a hardened structure to withstand the high velocity turbulent flow caused by the weir in the exit channel. Selected velocity measurements were made as shown in Plate 8 to determine the magnitude of velocities over the weir and in the exit channel. Velocities of 22 ft/sec were measured over the weir and velocities of 6.71 m/sec (25 ft/sec) were measured in the exit channel. Velocities of this magnitude require another stilling basin to dissipate the energy in the flow.

1V on 3.5H Approach Channel Side Slopes Experiments

Since the weir-rating curve at the structure was higher than desired and geotechnical conditions were being modified, additional modifications were necessary. One of these modifications was changing the side slope in the approach channel from 1V on 3H to 1V on 3.5H. Stage data were collected for the 2-, 10-, 100-, and 500-yr discharges to observe the effect of the milder side

[1] U.S. Army Corps of Engineers. (1990). "Hydraulic design of spillways," EM 1110-2-1603.

slopes. These data are shown in Plate 9 along with the original stages. No significant changes in stage were observed with the milder side slopes.

Type 2 Design Weir

The weir crest elevation was lowered from el 54.7 to el 53.0 to reduce the upstream stages determined for the type 1 weir design. This modification was designated the type 2 weir and is shown in Plate 10. The stages determined with the lower weir, type 2 design weir, are shown in Plate 11. Stage and discharge coordinates corresponding to this curve for the 2-yr frequency through Standard Project Flood events are shown in Table 5. For the 2-yr discharge of 223.4 cu m/sec (7,890 cfs) the stage was lowered 0.52 m (1.7 ft) and for the 500-yr discharge of 945.8 cu m/sec (33,400 cfs), the stage was lowered by 0.40 m (1.3 ft). These stages were considered acceptable. The effect on the upstream stage of the higher tailwater elevation is indicated by the solid data point at the SPF discharge of 1316.7 cu m/sec (46,500 cfs). For the high-tailwater elevation of 56.8 with the SPF discharge of 1316.7 cu m/sec (46,500 cfs), the upstream stage was el 73.5. With no tailwater effect, the upstream stage was 73.2. This was a small difference in stage.

Type 2 Design Stilling Basin

The floor of the stilling basin was lowered from el 8 to el 3 to improve the flow conditions in the basin for the tailwater conditions that would occur with the ultimate scour conditions and the Mississippi River stage at el 3 (minimum tailwater). This modification was designated the type 2 design stilling basin and the details are shown in Plate 10 along with the type 2 design weir details. The basin performance was improved over the type 1 design with the minimum tailwater conditions. A strong jump was observed in the stilling basin for the discharges greater than the 10-yr frequency and conditions in the exit channel were satisfactory. The basin action at the maximum tailwater conditions was acceptable. A submerged type jump existed in the basin and conditions in the exit channel were calm. With discharges less than the 10-year frequency, the flow exiting the stilling basin and entering the outflow channel tended to move to one side of the channel and form an eddy on the other side. This is often observed in hydraulics with a sudden expansion and low flows. The velocities in the exit channel were not excessive with these conditions and some deposition should be expected in the vicinity of the eddying flow.

With discharges less than or equal to the 2-yr frequency, the energy of the flow entering the stilling basin was not sufficient to cause a symmetrical jump in the basin. The flow tended to move to one side of the basin and an eddy existed on the other side. The energy dissipation was satisfactory, however the full width of the basin was not used. Table 5 lists the type of hydraulic jump observed in the type 2 stilling basin for the 2-yr frequency through SPF flows with high and low tailwater conditions.

Water-Surface Profiles

Water-surface profiles were measured for the 2-, 10-, 100-, 500-yr frequency, and SPF discharges along the right and left walls of the spillway and stilling basin for both high and low tailwater conditions. The profiles are shown in Plates 12-21. Tables 6-15 provide the water-surface elevation and station information for these profiles which is provided for use in determining hydraulic loads on the structure.

Velocity Measurements

Velocities were measured with the type 2 design weir and stilling basin for the discharges listed above and an additional flow of 566.3 cu m/sec (20,000 cfs). Velocities were measured throughout the depth of flow over the end sill to determine the magnitude and the distribution of flow entering the outflow channel. These measurements were also obtained for the high- and low-tailwater conditions for each discharge. The measurements made with the 2-yr flow of 223.4 cu m/sec (7,890 cfs) at 0.305 m (1.00 ft) over the end sill, the mid depth, and near the surface are shown in Plates 22-24. These velocities are also provided in Table 16, high-tailwater conditions, and Table 17, low-tailwater conditions along with the other discharges. The velocities measured 0.305 m (1 ft) over the end sill and shown in Plate 22 indicate the flow concentrates to the right side of the basin and this condition is more pronounced with the lower tailwater conditions. The flow conditions with a discharge of 223.4 cu m/sec (7,890 cfs) and tailwater el's of 17.0 and 52.5 are shown in Photos 1a and 1b, respectively. With the lower tailwater, there is an eddy on the left side of the stilling basin and flow is in the upstream direction on this side as seen in Photo 1a. This eddy occurs throughout the depth of flow with the low tailwater as observed in Plates 23 and 24. With the higher tailwater conditions, the flow becomes better distributed nearer the surface and is very tranquil in the outflow channel as shown in Photo 1b.

Velocities measured with a discharge of 410.6 cu m/sec (14,500 cfs) are shown in Plates 25-27 and also listed in Tables 16 and 17. Photos 2a and 2b illustrate the flow conditions in the outflow channel with this discharge and tailwater el's of 20.6 and 52.9. No eddies were observed over the end sill with the low tailwater, Plate 25, although the flow was still concentrated on the right side. The flow concentration was much less noticeable with the higher tailwater conditions. Velocities measured with a discharge of 566.3 cu m/sec (20,000 cfs) are shown in Plates 28-30 and also listed in Tables 16 and 17. No eddies were observed over the end sill with the low tailwater, Plate 28, and as also observed with the other discharges, most of the flow discharging from the end sill occurred from the mid depth to the surface on the right half of the basin. Also, conditions were improved for the higher tailwater elevations.

Velocities were also measured for discharges of 797.1, 945.8, and 1316.7 cu m/sec (28,150, 33,400, and 46,500 cfs) with high- and low-tailwater conditions. These velocities are shown in Plates 31-39 and listed in Tables 16

and 17. Similar tendencies were observed with these discharges as with a discharge of 566.3 cu m/sec (20,000 cfs). Most of the flow discharging from the end sill occurred from the mid depth to the surface on the right half of the basin for the low tailwater conditions. The distribution of flow discharging from the basin was improved for the higher tailwater elevations. The flow conditions in the stilling basin and the outflow channel with discharges of 797.1, 945.8, and 1316.7 cu m/sec (28,150, 33,400, and 46,500 cfs) are shown in Photos 3-5 for low-and high-tailwater conditions. The flows with high-tailwater conditions (Photos 3b, 4b, and 5b) show the tendency for the flow to move to one side of the outflow channel because of the large expansion at the end of the stilling basin.

Velocity measurements were also obtained at selected locations in the inflow and outflow channels to determine the extent of concrete paving and size of the riprap required in these areas. Velocities measured in the outflow channel are listed in Tables 18 and 19. Measurements made on the channel invert 11.43, 26.67, and 41.91 m (37.5, 87.5, and 137.5 ft) downstream from the end of the stilling basin are provided in Table 18 for discharges of 223.4 and 797.1 cu m/sec (7,890 and 28,150 cfs) and low-tailwater conditions. The highest velocity measured near the bottom was 2.62 m/sec (8.6 ft/sec) and occurred 11.43 m (37.5 ft) downstream from the end of the stilling basin in the middle of the channel with a discharge of 797.1 cu m/sec (28,150 cfs) (Table 18). This velocity is slightly lower than the 2.71 m/sec (8.9 ft/sec) velocity (Table 17) measured in the middle near the bottom at the end sill for the same discharge. The velocities measured in the same locations, at the end sill and 11.43 m (37.5 ft) downstream from the end of the stilling basin, for the discharge of 223.4 cu m/sec (7,890 cfs) were 2.62 m/sec (8.6 ft/sec) at the end sill and 2.26 m/sec (7.4 ft/sec) downstream. The highest velocity measured near the bottom at the end sill occurred on the right side of the basin with a discharge of 223.4 cu m/sec (7,890 cfs) and was 3.23 m/sec (10.6 ft/sec). The velocity measured 11.43 m (37.5 ft) downstream from the end of the stilling basin on the right side of the channel invert with a discharge of 223.4 cu m/sec (7,890 cfs) was 2.35 m/sec (7.7 ft/sec).

Velocities were also measured along the channel side slopes near the bottom for the high and low-tailwater conditions with a discharge of 797.1 cu m/sec (28,150 cfs). These measurements were made at a distance of 57.15 m (187.5 ft) downstream from the end of the stilling basin and are listed in Table 19. The measurements indicate the velocity ranges from 0.37 to 1.19 m/sec (1.2 to 3.9 ft/sec) with the high tailwater el of 54.3. Velocities up to 2.13 m/sec (7.0 ft/sec) were measured with the low tailwater and an upstream velocity of 1.77 m/sec (5.8 ft/sec) was measured near the water-surface on the left side of the channel for the low tailwater indicating eddies in this area.

The velocities measured in the outflow channel near the bottom at the end sill and in the channel downstream ranged from about 2.13 to 3.23 m/sec (7 to 10.6 ft/sec). The scour protection in the transition area immediately below the stilling basin should be sufficient to withstand velocities up to 3.35 m/sec (11 ft/sec). The area from the transition to approximately 30.48-m (100-ft) downstream from the basin should be protected for velocities up to 2.44 m/sec (8 ft/sec). The area from 30.48-m to 60.96-m (100-ft to 200-ft) downstream from

the end of the stilling basin should be protected for velocities up to 2.13 m/sec (7 ft/sec).

Velocities measured in the inflow channel near the invert and along the side slopes are provided in Tables 20 and 21 and illustrated in Plate 40. Inflow channel invert velocities measured for the 100-yr, 500-yr, and SPF discharges are provided in Table 20. The velocities were taken along the right and left sides of the channel invert at distances of 15.24, 30.48, 45.72 m (50, 100, and 150 ft) from the upstream edge of the weir. The highest velocity measured occurred with the SPF discharge on the left edge of the channel with the SPF discharge and was 2.87 m/sec (9.4 ft/sec). With the discharges of 945.8 and 1316.7 cu m/sec (33,400 and 46,500 cfs), most of the velocities measured near the bottom decreased as the flow approached the weir. This is because of a stronger vertical component of velocity that began developing upstream from the weir. This was not evident with a discharge of 797.1 cu m/sec (28,150 cfs). Velocities were measured along the side slope at distances of 45.72, 30.48, and 15.24 m (150, 100, and 50 ft) upstream from the weir with a discharge of 28,150 cfs. These measurements are provided in Table 21 and indicate the highest velocity measured on the side slope was 2.10 m/sec (6.9 ft/sec). This occurred 50 ft upstream from the weir crest at a horizontal distance of 50 ft out from the right toe.

Velocities just upstream from the weir crest were measured to determine the flow distribution over the weir because of the short approach in the model. These velocities were measured with a discharge of 945.8 cu m/sec (33,400 cfs), 10.97 m (36 ft) upstream from the weir crest and at el 63.2. This was the elevation halfway between the weir crest and the water-surface with this discharge and 10.97-m (36-ft) upstream from the weir. These velocities are provided in Table 22 and are distributed adequately considering the short approach. The distribution of the approach flow was not affecting the stilling basin and exit channel flow conditions.

The New Orleans District requested additional velocity measurements on the sides of the spillway and downstream from the stilling basin to help determine scour protection requirements. The locations of these velocity measurements are shown in Plate 41. The magnitude and direction of the velocities are provided in Tables 23-26 and are grouped by discharge. The direction of the velocity is oriented towards looking downstream. The velocities measured with a discharge of 797.1 cu m/sec (28,150 cfs) and listed in Table 23 indicate the flow outside the spillway and stilling basin walls was generally normal and towards the walls for the tailwater conditions shown. The highest velocities measured were at locations L10 and R10 (outside the stilling basin walls) with a tailwater of el 26.0 and were 1.49 and 1.52 m/sec (4.9 and 5.0 ft/sec), respectively. The highest velocity measured with a discharge of 945.8 cu m/sec (33,400 cfs) (Table 24) was 2.53 m/sec (8.3 ft/sec) and occurred just downstream from the end sill at location R11 with a tailwater el of 27.7. The velocity at this same location with a discharge of 1316.7 cu m/sec (46,500 cfs) and a tailwater el of 31.4 (Table 25) was 4.51 m/sec (14.8 ft/sec) and was the highest measured for this discharge. The highest velocity measured at the locations downstream of the end sill with a discharge of 223.4 cu m/sec (7,890 cfs) and a tailwater el of 17.0 (Table 26) was 2.13 m/sec (7.0 ft/sec) and occurred at location R12.

4 Summary and Conclusions

Experiments to evaluate the hydraulic performance of the Lilly Bayou Structure revealed the structure-required modifications to achieve the desired hydraulic performance. The performance of the original design-stilling basin in this study was not acceptable for the newly established tailwater conditions that will occur with the ultimate scour in the outflow channel and a low-stage on the Mississippi River. For the tailwater conditions with the ultimate scour tailwater rating curve, an unstable jump occurred in the basin and was on the verge of sweeping completely out of the stilling basin. The original design basin performed satisfactorily with the higher tailwater conditions.

The headwater-rating curve determined for the original design weir was not as efficient as desired because of other project requirements and modifications since the previous model study (Hite 1994). Changes to the approach channel cross section were not effective in reducing the stages. Since flow conditions at the approach walls were favorable (no significant abutment contractions and smooth entrance flow), no further modifications were made in this area. The weir crest elevation was lowered by 0.52 m (1.7 ft), from el 54.7 to el 53, to achieve the desired stages. With this crest elevation, the stages were considered acceptable for discharges up to the SPF. Since flow conditions for the new rectangular approach walls were favorable (no significant abutment contractions and smooth entrance flow) no further modifications were made to these areas.

The stilling basin was lowered from el 8 to el 3 to improve the performance with the low tailwaters. With the stilling basin floor at el 8, an unstable forced jump condition was observed for low tailwater stages. With the stilling basin floor at el 3, a strong hydraulic jump occurred in the basin with the tailwaters resulting from ultimate scour in the outflow channel and the Mississippi River stage at el 3. This jump was effective in dissipating the energy of the flow and no strong concentrated flows were present in the outflow channel for the higher discharges. Basin performance and flow conditions in the outflow channel were improved for the higher tailwater conditions.

Scour protection is needed both upstream and downstream from the structure to ensure the functional performance. Velocities up to 3.35 m/sec (11 ft/sec) should be expected near the bottom just downstream from the stilling basin. The magnitude decreases in the downstream direction and velocities near 2.13 m/sec (7 ft/sec) should be expected in the ouflow channel with the 100-yr discharge of 797.1 cu m/sec (28,150 cfs) and low tailwater up to 60.96 m (200 ft) away from the end of the basin. The velocities in the inflow channel near the bottom of the

invert and side slope for the 100-yr discharge of 797.1 cu m/sec (28,150 cfs) should be between 1.52 and 1.83 m/sec (5 and 6 ft/sec). These velocities will be higher with higher discharges.

The performance of the Lilly Bayou Structure with modifications was considered acceptable overall for discharges up to the SPF for both the high and low tailwater conditions. Flow conditions were improved from those observed in the previous study (Hite 1994) and are particularly good in all areas upstream of the stilling basin. The performance of the stilling basin for flows less than the 2-yr discharge of 223.4 cu m/sec (7,890 cfs) was less than optimum. The basin is oversized for these flows and eddies and nonuniform velocity distributions result. However, these are mostly contained within the basin and adequate energy dissipation was observed. Flow concentrations in the basin and outflow channel should be expected during low discharges. This could result in deposition in areas of low flow. Any deposited material is expected to be removed by higher discharges. Because of the size of the exit channel required for soil stability, the distribution of flow in the channel is not uniform. The flow discharging from the stilling basin experiences an abrupt expansion and tends to move to one side of the outflow channel. No excessive velocities result from this nonuniform flow because of the large size of the channel.

Table 1
Comite River Diversion Project Diversion Channel Stage Control Structure ("Lilly Bayou Structure") Tailwater Rating Curve Coordinates

Frequency Yrs.	Discharge, cu m/sec (cfs)	Existing Channels		Ultimate Scour	
		Miss. River El 3	Miss. River El 52.3	Miss. River El 3	Miss. River El 52.3
	0 (0)	8.0			
1-Year	153.8 (5430)	45.7	52.4	15.3	52.3
2-Year	223.4 (7890)	46.7	52.5	17.0	52.3
5-Year	306.1 (10810)	47.7	52.6	18.7	52.3
10-Year	410.6 (14500)	48.8	52.9	20.6	52.4
25-Year	543.7 (19200)	50.0	53.3	22.7	52.4
50-Year	685.3 (24200)	51.3	53.8	24.6	52.5
100-Year	797.1 (28150)	52.2	54.3	26.0	52.5
200-Year	880.9 (31110)	52.8	54.7	27.0	52.6
500-Year	945.8 (33400)	53.3	55.0	27.7	52.6
SPF	1316.7 (46500)	55.9	56.8	31.4	52.9
PMF	2375.8 (83900)	61.9	62.1	39.7	54.1

Note: All elevations (el) cited herein are in feet referenced to the National Geodetic Datum (NGVD) (to convert feet to meters, multiply number of feet by 0.3048).

Table 2
Stilling Basin Action with Rising Stages

Discharge cu m/sec (cfs)	Jump Forms		Stable Jump		Undular Jump		Submerged Flow	
	Pool El	Tailwater El	Pool El	Tailwater El	Pool El	Tailwater El	Pool El	Tailwater El
0 (0)								
113.3 (4000)			59.7		59.8	59.4	61.8	61.3
169.9 (6000)	61.4	14.9	61.4	17.0	61.2	60.7	62.4	62.5
212.4 (7500)	62.2	18.7	62.2	19.4	62.4	61.9	64.0	63.7
283.2 (10000)	62.8	20.5	62.8	21.7	63.0	63.2	65.1	65.5
354.0 (12500)	63.4	21.0	63.4	22.3	64.1	63.8	66.0	66.4
424.8 (15000)	65.0	24.1	65.0	24.9	65.4	65.3	67.2	67.2
495.5 (17500)	66.2	26.0	66.2	26.7	67.0	66.7	69.2	69.3
566.3 (20000)	67.1	27.5	67.1	27.7	67.9	67.6	70.5	70.4
637.1 (22500)	67.9	27.7	67.9	28.4	68.6	68.1	71.6	71.3
707.9 (25000)	69.0	28.5	69.0	29.6	69.8	69.6		
778.7 (27500)	69.3	29.4	69.3	30.8	70.5	70.0		
849.5 (30000)	70.5	29.6	70.5	32.0	71.3	71.0		
945.8 (33400)	71.2	32.9	71.2	33.4	73.7	73.2		

Note: Pool el measured 54.86 m (180 ft) upstream from weir crest. Tailwater el measured 121.92 (400 ft) downstream from toe of spillway.

Table 3
Stilling Basin Action with Falling Stages

Discharge cu m/sec (cfs)	Jump Washes Out		Submerged Jump		Undular Jump		Submerged Flow	
	Pool El	Tailwater El	Pool El	Tailwater El	Pool El	Tailwater El	Pool El	Tailwater El
0 (0)	54.7							
113.3 (4000)	59.7		59.7	58.4	59.7	59.1	61.8	61.4
169.9 (6000)	61.0	14.7	61.2	60.3	62.3	61.9	62.4	62.3
212.4 (7500)	62.0	19.0	62.0	61.3	62.0	61.9	64.0	63.7
283.2 (10000)	62.8	21.1	63.4	63.4	63.3	63.2	65.1	65.5
354.9 (12500)	63.4	22.7	63.8	49.3	64.2	64.1	66.0	66.4
424.8 (15000)	65.0	24.0	65.2	64.6	65.3	65.2	74.4	67.2
495.5 (17500)	66.2	26.5	66.9	66.7	67.0	67.0	69.2	69.3
566.3 (20000)	67.1	26.7	67.7	67.4	68.1	68.1	70.5	70.4
637.1 (22500)	67.9	27.2	68.6	68.3	68.9	68.8	71.6	71.3
707.9 (25000)	69.0	28.8	69.4	68.0	69.7	68.6		
778.7 (27500)	69.3	28.9	69.8	68.8	70.4	69.5		
849.5 (30000)	70.5	29.8	71.8	70.4	71.8	71.1		
945.8 (33400)	71.2	31.0	73.3	71.5	73.7	71.8		

Note: Pool El measured 54.86 m (180 ft) upstream from weir crest. Tailwater El measured 121.92 m (400 ft) downstream from toe of spillway.

Table 4 Original Design Stilling Basin Performance						
Discharge cu m/sec (cfs)	Frequency Yrs	Pool El	Tailwater El	Type Hyd. Jump	Tailwater El	Type Hyd. Jump
0 (0)	No Flow					
223.4 (7890)	2	62.0	17.0	Forced	52.5	Submerged
410.6 (14500)	10	65.9	20.6	Forced	52.9	Submerged
797.1 (28150)	100	70.2	26.0	Forced	54.3	Submerged
945.8 (33400)	500	71.5	27.7	Forced	55.0	Submerged
Note: Pool el measured 54.86 m (180 ft) upstream from weir crest. Tailwater el measured 121.92 (400 ft) downstream from end of stilling basin.						

Table 5 Type 2 Design Weir Rating and Type 2 Design Stilling Basin Performance						
Discharge Cfs	Frequency Yrs	Pool El	Tailwater El	Type Hyd. Jump	Tailwater El	Type Hyd. Jump
0 (0)	No Flow					
223.4 (7890)	2	60.3	17.0	Unsymmetrical	52.5	Submerged
410.6 (14500)	10	63.1	20.6	Strong	52.9	Submerged
797.1 (28150)	100	68.8	26.0	Strong	54.3	Submerged
945.8 (33400)	500	70.2	27.7	Strong	55.0	Submerged
1316.7 (46500)	SPF	73.2	31.4	Strong	56.8	Submerged
Note: Pool el measured 54.86 m (180 ft) upstream from weir crest. Tailwater el measured 121.92 (400 ft) downstream from end of stilling basin.						

Table 6 Water-Surface Elevations Type 2 Design Weir and Stilling Basin Discharge -2Yr- 223.4 cu m/sec (7,890 cfs) Tailwater El 52.5		
	Water-Surface El	
Distance from D/S Edge Weir Crest, m (ft)	Right Wall	Left Wall
17.56 (57.6)	60.6	60.6
13.17 (43.2)	60.6	60.6
8.78 (28.8)	60.5	60.5
4.39 (14.4)	59.6	59.8
0.00 (0)	57.9	57.9
-4.39 (-14.4)	54.0	53.7
-13.17 (-43.2)	47.6	47.1
-17.56 (-57.6)	49.8	49.5
-21.95 (-72)	50.8	50.8
-32.92 (-108)	52.2	52.2

Table 7
Water-Surface Elevations Type 2 Design Weir and Stilling Basin
Discharge -2Yr- 223.4 cu m/sec (7,890 cfs) Tailwater El 17.0

Distance from D/S Edge Weir Crest, m (ft)	Water-Surface El	
	Right Wall	Left Wall
17.56 (57.6)	60.6	60.6
13.17 (43.2)	60.6	60.6
8.78 (28.8)	60.5	60.5
4.39 (14.4)	59.4	59.7
0.00 (0)	57.5	57.4
-4.39 (-14.4)	53.5	53.5
-10.97 (-36)	48.4	48.3
-21.95 (-72)	41.2	40.9
-32.92 (-108)	33.5	33.6
-43.89 (-144)	26.4	25.7
-54.86 (-180)	19.2	18.8
-65.84 (-216)	11.5	11.5
-70.23 (-230.4)	9.5	9.5
-74.62 (-244.8)	12.1	14.0
-81.20 (-266.4)	14.9	15.6
-87.78 (-288)	15.1	16.9
-98.76 (-324)	17.3	15.4
-109.73 (-360)	16.6	16.3
-120.70 (-396)	16.2	16.4

Table 8
Water-Surface Elevations Type 2 Design Weir and Stilling Basin
Discharge -10Yr-410.6 cu m/sec (14,500 cfs) Tailwater El 52.9

Distance from D/S Edge Weir Crest, m (ft)	Water-Surface El	
	Right Wall	Left Wall
17.56 (57.6)	63.1	63.1
13.17 (43.2)	63.0	63.1
8.78 (28.8)	62.7	62.7
4.39 (14.4)	61.7	62.0
0.00 (0)	59.6	59.7
-4.39 (-14.4)	55.2	55.3
-10.97 (-36)	50.1	49.8
-15.36 (-50.4)	46.6	46.4
-21.95 (-72)	49.1	49.4
-27.43 (-90)	50.9	50.7
-32.92 (-108)	51.3	51.3
-43.89 (-144)	52.1	51.9

Table 9 Water-Surface Elevations Type 2 Design Weir and Stilling Basin Discharge -10Yr- 410.6 cu m/sec (14,500 cfs) Tailwater El 20.6		
Distance from D/S Edge Weir Crest, m (ft)	Water-Surface El	
	Right Wall	Left Wall
17.56 (57.6)	63.1	63.1
13.17 (43.2)	63.0	63.0
8.78 (28.8)	62.7	62.6
4.39 (14.4)	61.7	62.0
0.00 (0)	59.4	59.4
-4.39 (-14.4)	55.3	55.3
-10.97 (-36)	50.2	49.8
-21.95 (-72)	42.1	42.0
-32.92 (-108)	34.7	34.7
-43.89 (-144)	27.3	26.6
-54.86 (-180)	20.1	19.5
-65.84 (-216)	12.1	12.0
-68.58 (-225)	10.8	10.5
-76.81 (-252)	15.0	15.3
-87.78 (-288)	20.2	20.5
-98.76 (-324)	21.7	20.6
-109.73 (-360)	20.5	20.5
-120.70 (-396)	20.6	20.6

Table 10 Water-Surface Elevations Type 2 Design Weir and Stilling Basin Discharge -100Yr - 797.1 cu m/sec (28,150 cfs) Tailwater El 54.3		
Distance from D/S Edge Weir Crest, m (ft)	Water-Surface El	
	Right Wall	Left Wall
15.24 (50.0)	69.0	68.8
7.62 (25.0)	68.1	67.5
0 (0.0)	63.4	63.4
-7.62 (-25.0)	56.6	54.6
-15.24 (-50.0)	50.2	48.7
-22.86 (-75.0)	51.4	47.8

Table 11 Water-Surface Elevations Type 2 Design Weir and Stilling Basin Discharge -100Yr- 797.1 cu m/sec (28,150 cfs) Tailwater El 26.0		
Distance from D/S Edge Weir Crest, m (ft)	Water-Surface El	
	Right Wall	Left Wall
17.56 (57.6)	68.6	68.6
13.17 (43.2)	68.4	68.3
8.78 (28.8)	67.4	67.4
4.39 (14.4)	66.3	66.5
0.00 (0.0)	63.5	63.4
-5.49 (-18.0)	57.3	56.2
-16.46 (-54.0)	48.8	47.4
-32.92 (-108.0)	36.1	36.1
-43.89 (-144.0)	29.2	28.3
-54.86 (-180.0)	21.9	20.2
-65.84 (-216.0)	13.4	13.0
-71.32 (-234.0)	10.0	9.4
-76.81 (-252.0)	12.0	12.3
-82.30 (-270.0)	16.1	15.3
-87.78 (-288.0)	20.6	20.6
-96.56 (-316.8)	26.4	25.7
-106.44 (-349.2)	23.1	24.4
-120.70 (-396.0)	24.8	25.0

Table 12
Water-Surface Elevations Type 2 Design Weir and Stilling Basin
Discharge -500Yr- 945.8 cu m/sec (33,400 cfs) Tailwater El 55.8

Distance from D/S Edge Weir Crest, m (ft)	Water-Surface El	
	Right Wall	Left Wall
15.24 (50.0)	69.6	69.8
7.62 (25.0)	68.9	68.7
0 (0.0)	64.4	64.7
-7.62 (25.0)	57.4	57.0
-15.24 (50.0)	50.8	50.2
-22.86 (75.0)	47.6	47.5

Table 13
Water-Surface Elevations Type 2 Design Weir and Stilling Basin
Discharge -500Yr - 945.8 cu m/sec (33,400 cfs) Tailwater El 27.7

Distance from D/S Edge Weir Crest, m (ft)	Water-Surface El	
	Right Wall	Left Wall
17.56 (57.6)	69.8	69.8
13.17 (43.2)	69.5	69.5
8.78 (28.8)	68.7	68.7
4.39 (14.4)	67.0	67.4
0.00 (0.0)	64.1	64.2
-5.49 (-18.0)	59.5	59.5
-10.97 (-36.0)	54.6	53.5
-21.95 (-72.0)	46.4	45.9
-32.92 (-108.0)	38.0	38.4
-43.89 (-144.0)	31.1	30.1
-54.86 (-180.0)	24.2	22.9
-65.84 (-216.0)	15.8	15.2
-73.52 (-241.2)	12.1	11.2
-82.30 (-270.0)	20.5	21.3
-93.27 (-306.0)	27.5	29.2
-104.24 (-342.0)	28.7	27.6
-115.21 (-378.0)	28.4	28.0
-126.19 (-414.0)	28.2	27.8

Table 14
Water-Surface Elevations Type 2 Design Weir and Stilling Basin
Discharge -SPF- 1316.7 cu m/sec (46,500 cfs) Tailwater El 56.8

Distance from D/S Edge Weir Crest, m (ft)	Water-Surface El	
	Right Wall	Left Wall
17.56 (57.6)	73.2	73.6
13.17 (43.2)	73.2	73.6
8.78 (28.8)	72.0	72.7
4.39 (14.4)	70.6	71.0
0.00 (0.0)	66.9	67.9
-4.39 (-14.4)	62.8	63.9
-8.78 (-28.8)	58.5	58.8
-13.17 (-43.2)	55.3	54.7
-21.95 (-72.0)	48.4	48.1
-25.24 (-82.8)	45.1	45.0
-32.92 (-108.0)	49.9	50.2
-43.89 (-144.0)	54.3	54.3
-54.86 (-180.0)	55.1	55.1
-65.84 (-216.0)	55.1	55.1

Table 15
Water-Surface Elevations Type 2 Design Weir and Stilling Basin
Discharge -SPF- 1316.7 cu m/sec (46,500 cfs) Tailwater El 31.4

Distance from D/S Edge Weir Crest, m (ft)	Water-Surface El	
	Right Wall	Left Wall
17.56 (57.6)	73.4	73.5
13.17 (43.2)	72.7	73.5
8.78 (28.8)	71.9	72.4
4.39 (14.4)	70.3	71.0
0.00 (0.0)	66.8	68.3
-4.39 (-14.4)	63.0	64.2
-8.78 (-28.8)	59.2	59.2
-13.17 (-46.8)	54.5	54.4
-21.95 (-72.0)	48.1	48.1
-25.24 (-108.0)	39.5	40.4
-32.92 (-144.0)	31.9	31.4
-43.89 (-180.0)	24.5	23.6
-54.86 (-201.6)	19.1	18.9
-65.84 (-234.0)	22.5	23.1
-76.81 (-252.0)	26.6	26.2
-87.78 (-288.0)	31.3	31.3
-98.76 (-324.0)	33.7	35.0
-109.73 (-360.0)	33.3	33.6
-120.70 (-396.0)	32.6	33.3

Table 16
Velocities Over End Sill High Tailwater Conditions Type 2 Design Weir and Stilling Basin

Discharge cu m/sec (cfs)	Tailwater El	Velocities in m/sec (ft/sec)								
		Left Side			Center			Right Side		
		Bottom	Middle	Top	Bottom	Middle	Top	Bottom	Middle	Top
223.4 (7890)	52.5	0.03 (0.1)	0.40 (1.3)	0.24 (0.8)	0.43 (1.4)	0.37 (1.2)	0.61 (2.0)2	0.85 (2.8)	1.13 (3.7)	0.94 (3.1)
410.6 (14500)	52.9	0.61 (2.0)	1.01 (3.3)	0.55 (1.8)	0.70 (2.3)	1.10 (3.6)	0.58 (1.9)	0.85 (2.8)	1.65 (5.4)	0.85 (2.8)
566.3 (20000)	53.4	1.06 (3.4)	1.04 (3.4)	1.74 (5.7)	1.07 (3.5)	1.04 (3.4)	0.61 (2.0)	1.25 (4.1)	2.47 (8.1)	1.28 (4.2)
797.1 (28150)	54.3	1.36 (4.5)	2.97 (9.7)	1.61 (5.3)	1.32 (4.3)	1.40 (4.6)	0.83 (2.7)	1.65 (5.4)	3.24 (10.6)	1.37 (4.5)
948.6 (33500)	55.0	1.49 (4.9)	3.23 (10.6)	2.53 (8.3)	1.71 (5.6)	1.71 (5.6)	0.88 (2.9)	1.86 (6.1)	3.57 (11.7)	2.29 (7.5)
1316.7 (46500)	56.8	1.89 (6.2)	4.94 (16.2)	2.90 (9.5)	2.53 (8.3)	2.32 (7.6)	0.98 (3.2)	2.07 (6.8)	5.06 (16.6)	2.16 (7.1)

Table 17
Velocities Over End Sill Low Tailwater Conditions Type 2 Design Weir and Stilling Basin

Discharge cu m/sec (cfs)	Tailwater El	Velocities in m/sec (ft/sec)								
		Left Side			Center			Right Side		
		Bottom	Middle	Top	Bottom	Middle	Top	Bottom	Middle	Top
223.4 (7890)	17.0	-0.85 (-2.8)	-0.91 (-3.0)	-0.52 (-1.7)	2.62 (8.6)	3.20 (10.5)	3.81 (12.5)	3.23 (10.6)	3.08 (10.1)	2.99 (9.8)
410.6 (14500)	20.6	1.07 (3.5)	0.88 (2.9)	0.76 (2.5)	1.89 (6.2)	2.41 (7.9)	3.11 (10.2)	2.53 (8.3)	2.65 (8.7)	3.11 (10.2)
566.3 (20000)	23.0	1.31 (4.3)	1.52 (5.0)	2.44 (8.0)	2.38 (7.8)	3.72 (12.2)	4.66 (15.3)	2.50 (8.2)	3.26 (10.7)	4.36 (14.3)
797.1 (28150)	26.0	0.98 (3.2)	3.84 (12.6)	3.20 (10.5)	2.71 (8.9)	4.66 (15.3)	4.88 (16.0)	2.35 (7.7)	4.36 (14.3)	5.43 (17.8)
948.6 (33500)	27.7	0.82 (2.7)	1.58 (5.2)	4.02 (13.2)	2.19 (7.2)	4.33 (14.2)	5.06 (16.6)	2.50 (8.2)	4.57 (15.0)	5.52 (18.1)
1316.7 (46500)	31.4	1.49 (4.9)	4.82 (15.8)	3.99 (13.1)	10.4 (3.17)	5.00 (16.4)	4.11 (13.5)	3.63 (11.9)	7.28 (23.9)	5.39 (17.7)

Table 18
Invert Velocities in the Outflow Channel Type 2 Design Weir and Stilling Basin

Discharge cu m/sec (cfs)	Tailwater El	Distance from End of Basin, m (ft)	Velocity in m/sec (ft/sec) Location in Outflow Channel		
			Right Toe	Center	Left Toe
797.1 (28,150)	26.0	11.43 (37.5)	2.13 (7.0)	2.62 (8.6)	0.88 (2.9)
797.1 (28,150)	26.0	26.67 (87.5)	2.32 (7.6)	2.35 (7.7)	1.04 (3.4)
797.1 (28,150)	26.0	41.91 (137.5)	2.16 (7.1)	2.29 (7.5)	0.94 (3.1)
223.4 (7,890)	17.0	11.43 (37.5)	2.35 (7.7)	2.26 (7.4)	0.40 (1.3)
223.4 (7,890)	17.0	26.67 (87.5)	1.86 (6.1)	1.98 (6.5)	0.40 (1.3)
223.4 (7,890)	17.0	41.91 (137.5)	1.80 (5.9)	1.89 (6.2)	0.82 (2.7)

Note: Velocities measured 0.3048 m (1 ft) above invert.

Table 19
Velocities on Side Slopes of Outflow Channel Type 2 Design Weir and Stilling Basin 57.15 m (187.5 ft) Downstream from End of Basin

Discharge, cu m/sec (cfs)	Tailwater El	Hoirzontal Distance From Toe of Slope, Ft	Velocity, in m/sec (ft/sec)	
			Right	Left
797.1 (28,150)	54.3	7.62 (25.0)	1.19 (3.9)	0.58 (1.9)
		15.24 (50.0)	0.85 (2.8)	0.49 (1.6)
		22.86 (75)	0.94 (3.1)	0.55 (1.8)
		30.49 (100.0)	0.91 (3.0)	0.37 (1.2)
		38.1 (125.0)	0.79 (2.6)	0.37 (1.2)
797.1 (28,150)	26.0	7.62 (25.0)	2.13 (7.0)	0.55 (1.8)
		15.24 (50.0)	0.61 (2.0)	-1.77 (-5.8)

Note: Velocities measured 0.3048 m (1 ft) above bottom.

Table 20
Invert Velocities in the Inflow Channel Type 2 Design Weir and Stilling Basin

Discharge cu m/sec (ft)	Distance from U/S Edge of Weir, m (ft)	Velocity in m/sec (ft/sec) Location in Inflow Channel	
		Right Toe	Left Toe
797.1 28,150	15.24 (50.0)	1.37 (4.5)	1.07 (3.5)
797.1 28,150	30.48 (100.0)	1.43 (4.7)	1.19 (3.9)
797.1 28,150	45.72 (150.0)	1.65 (5.4)	1.68 (5.5)
945.8 33,400	15.24 (50.0)	1.62 (5.3)	1.71 (5.6)
945.8 33,400	30.48 (100.0)	1.58 (5.2)	1.83 (6.0)
945.8 33,400	45.72 (150.0)	1.74 (5.7)	1.89 (6.2)
1316.7 46,500	15.24 (50.0)	1.43 (4.7)	2.04 (6.7)
1316.7 46,500	30.48 (100.0)	2.35 (7.7)	2.47 (8.1)
1316.7 46,500	45.72 (150.0)	2.53 (8.3)	2.87 (9.4)

Note: Velocities measured 0.3048 m (1 ft) above invert.

Table 21
Velocities on Side Slopes of Inflow Channel Type 2 Design Weir and Stilling Basin

Discharge m (cfs)	Horizontal Distance From Toe of Slope, m (ft)	Velocity, m/sec (ft/sec) Right	Left
797.1 (28,150)	7.62 (25)	1.37 (4.5)	1.86 (6.1)
	15.24 (50)	1.77 (5.8)	1.92 (6.3)
	22.86 (75)	1.86 (6.1)	1.83 (6.0)
	30.48 (100)	1.34 (4.4)	0.98 (3.2)
30.48 m (100 ft) Upstream from Upstream Edge of Weir Crest			
797.1 (28,150)	7.62 (25)	1.31 (4.3)	1.74 (5.7)
	15.24 (50)	1.89 (6.2)	2.07 (6.8)
	22.86 (75)	1.92 (6.3)	1.95 (6.4)
	30.48 (100)	0.67 (2.2)	1.04 (3.4)
15.24 m (50 ft) Upstream from Upstream Edge of Weir Crest			
797.1 (28,150)	7.62 (25)	1.62 (5.3)	1.62 (5.3)
	15.24 (50)	2.10 (6.9)	2.04 (6.7)
	22.86 (75)	1.25 (4.1)	1.40 (4.6)
Note: Velocities measured 0.3048 m (1 ft) above invert			

Table 22
Velocities of 10.97 m (36 ft) Upstream from Crest Discharge 795.8 cu m/sec (33,400 cfs) Velocity El 63.2

Distance from Right Wall, m (ft)	Velocity m/sec (ft/sec)
1.10 (3.6)	2.62 (8.6)
7.62 (25)	3.23 (10.6)
15.24 (50)	2.87 (9.4)
22.86 (75)	2.77 (9.1)
30.48 (100)	2.77 (9.1)
38.1 (125)	2.99 (9.8)
39.14 (128.4)	2.74 (9.0)

Table 23
Velocities with Discharge of 797.1 cu m/sec (28,150 cfs) Type 2 Design Weir Type 2 Design Stilling Basin

Velocity Location	Velocity, m (ft/sec)	Direction
Tailwater El 54.3		
L1	0.46 (1.5)	Left to Right
L2	0.37 (1.2)	Left to Right
L3	1.07 (3.5)	Left to Right
L4	1.19 (3.9)	Lower Left to Upper Right
R1	0.43 (1.4)	Right to Left
R2	0.58 (1.9)	Right to Left
R3	1.28 (4.2)	Right to Left
R4	1.43 (4.7)	Lower Right to Upper Left
Tailwater El 40.0		
L5	1.25 (4.1)	Left to Right
L6	1.04 (3.4)	Left to Right
R5	1.37 (4.5)	Right to Left
R6	1.46 (4.8)	Right to Left
Tailwater El 26.0		
L9	0.52 (1.7)	Left to Right
L10	1.49 (4.9)	Left to Right
R9	0.94 (3.1)	Right to Left
R10	1.52 (5.0)	Right to Left

Table 24
Velocities with Discharge of 945.8 cu m/sec (33,400 cfs) Type 2 Design Weir Type 2 Design Stilling Basin

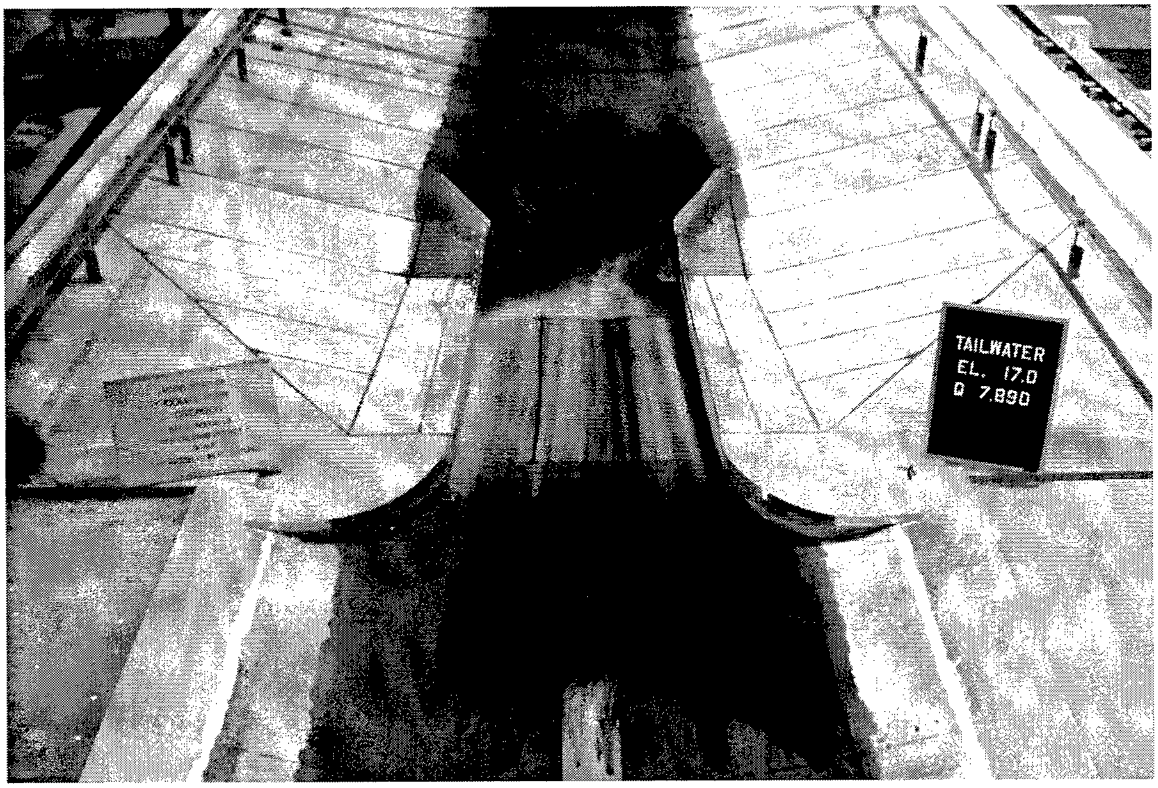
Velocity Location	Velocity, m/sec (ft/sec)	Direction
	Tailwater El 55.0	
L1	0.55 (1.8)	Left to Right
L2	0.43 (1.4)	Left to Right
L3	1.34 (4.4)	Left to Right
L4	1.13 (3.7)	Lower Left to Upper Right
R1	0.46 (1.5)	Right to Left
R2	0.52 (1.7)	Right to Left
R3	1.58 (5.2)	Right to Left
R4	1.62 (5.3)	Lower Right to Upper Left
	Tailwater El 40.0	
L5	1.43 (4.7)	Left to Right
L6	1.37 (4.5)	Left to Right
R5	1.34 (4.4)	Right to Left
R6	1.52 (5.0)	Right to Left
	Tailwater El 27.7	
L9	0.64 (2.1)	Left to Right
L10	1.46 (4.8)	Left to Right
R9	0.91 (3.0)	Right to Left
R10	1.77 (5.8)	Right to Left
L11	0.73 (2.4)	Downstream
L12	0.55 (1.8)	Downstream
R11	2.53 (8.3)	Downstream
R12	2.29 (7.5)	Downstream

Table 25
Velocities with Discharge of 1316.7 cu m/sec (46,500 cfs) Type 2 Design Weir Type 2 Design Stilling Basin

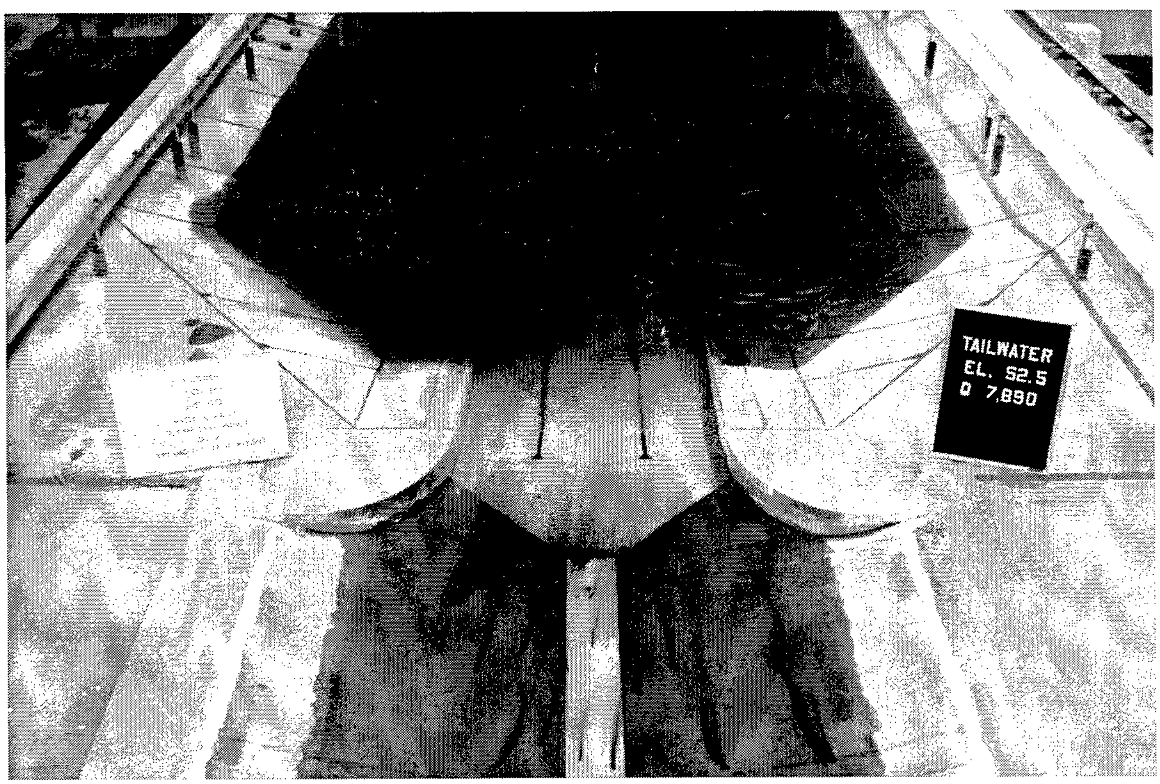
Velocity Location	Velocity m/sec (ft/sec)	Direction
	Tailwater El 56.8	
L1	0.58 (1.9)	Left to Right
L2	0.64 (2.1)	Left to Right
L3	2.01 (6.6)	Left to Right
L4	2.13 (7.0)	Lower Left to Upper Right
R1	0.67 (2.2)	Right to Left
R2	0.43 (1.4)	Right to Left
R3	1.89 (6.2)	Right to Left
R4	2.07 (6.8)	Lower Right to Upper Left
	Tailwater El 40.0	
L5	1.16 (3.8)	Left to Right
L6	0.85 (2.8)	Left to Right
R5	1.04 (3.4)	Right to Left
R6	0.82 (2.7)	Right to Left
	Tailwater El 31.4	
L7	1.58 (5.2)	Left to Right
L8	1.01 (3.3)	Left to Right
R7	1.83 (6.0)	Right to Left
R8	0.82 (2.7)	Right to Left
L9	1.43 (4.7)	Left to Right
L10	2.01 (6.6)	Left to Right
R9	1.22 (4.0)	Right to Left
R10	2.47 (8.1)	Right to Left
L11	0.85 (2.8)	Downstream
L12	0.67 (2.2)	Downstream
R11	4.51 (14.8)	Downstream
R12	3.96 (13.0)	Downstream

Table 26
Velocities with Discharge of 223.4 cu m/sec (7,890 cfs) Type 2 Design Weir Type 2 Design Stilling Basin Tailwater El 17.0

Velocity Location	Velocity, m/sec (ft/sec)	Direction
L11	0.43 (1.4)	Downstream
L12	0.43 (1.4)	Downstream
R11	1.98 (6.5)	Downstream
R12	2.13 (7.0)	Downstream

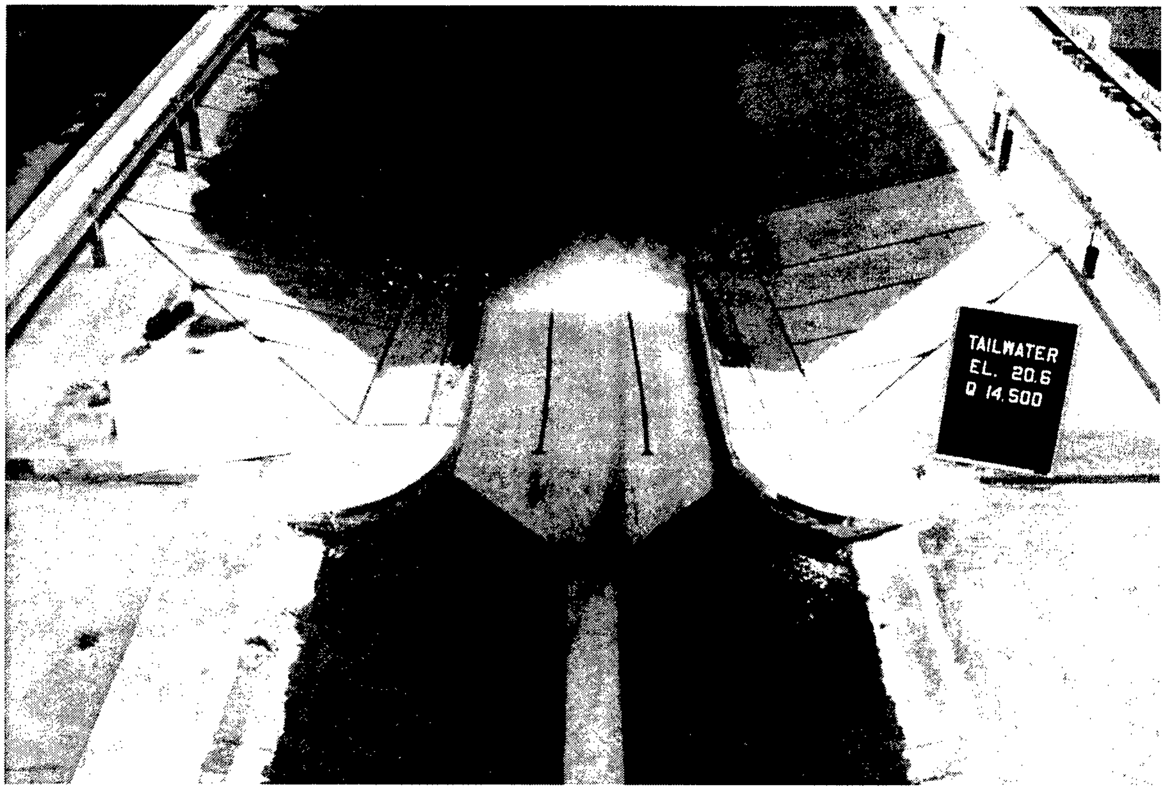


a. Tailwater el 17.0

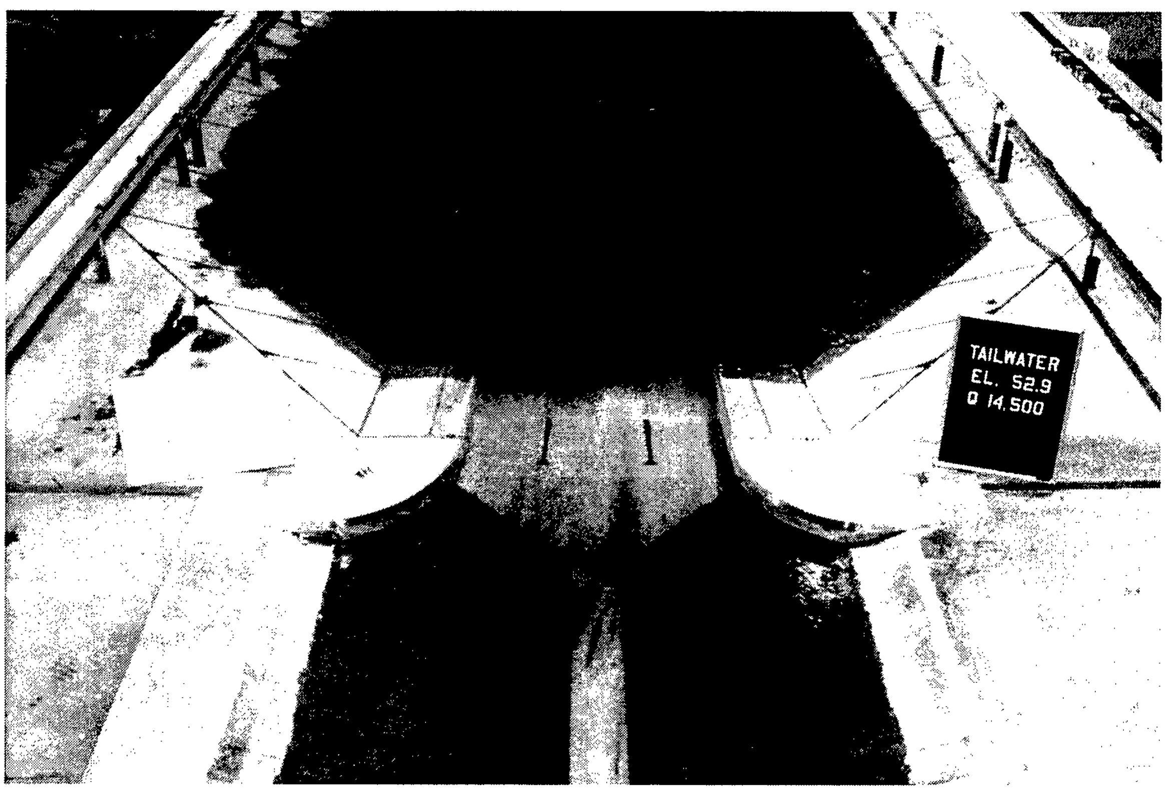


b. Tailwater el 52.5

Photo 1. Type 2 design weir and stilling basin with 2-yr discharge of 223.4 cu m/sec (7,890 cfs)

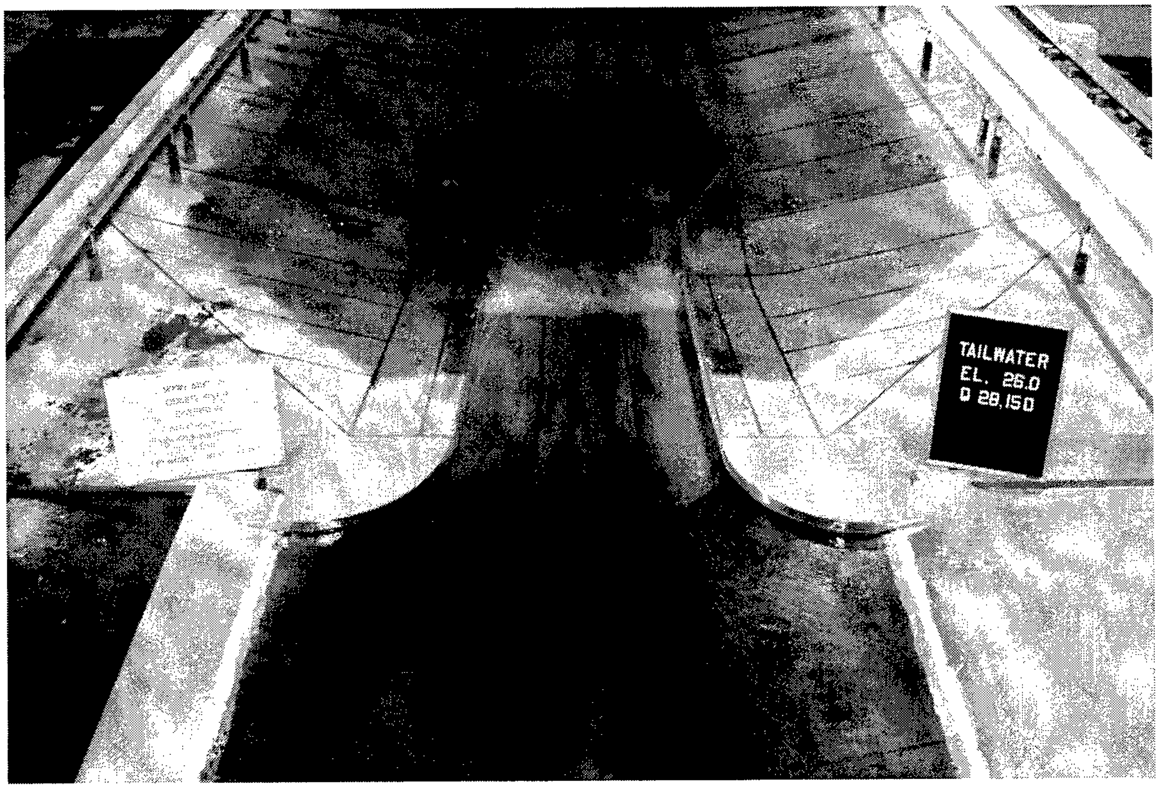


a. Tailwater el 20.6

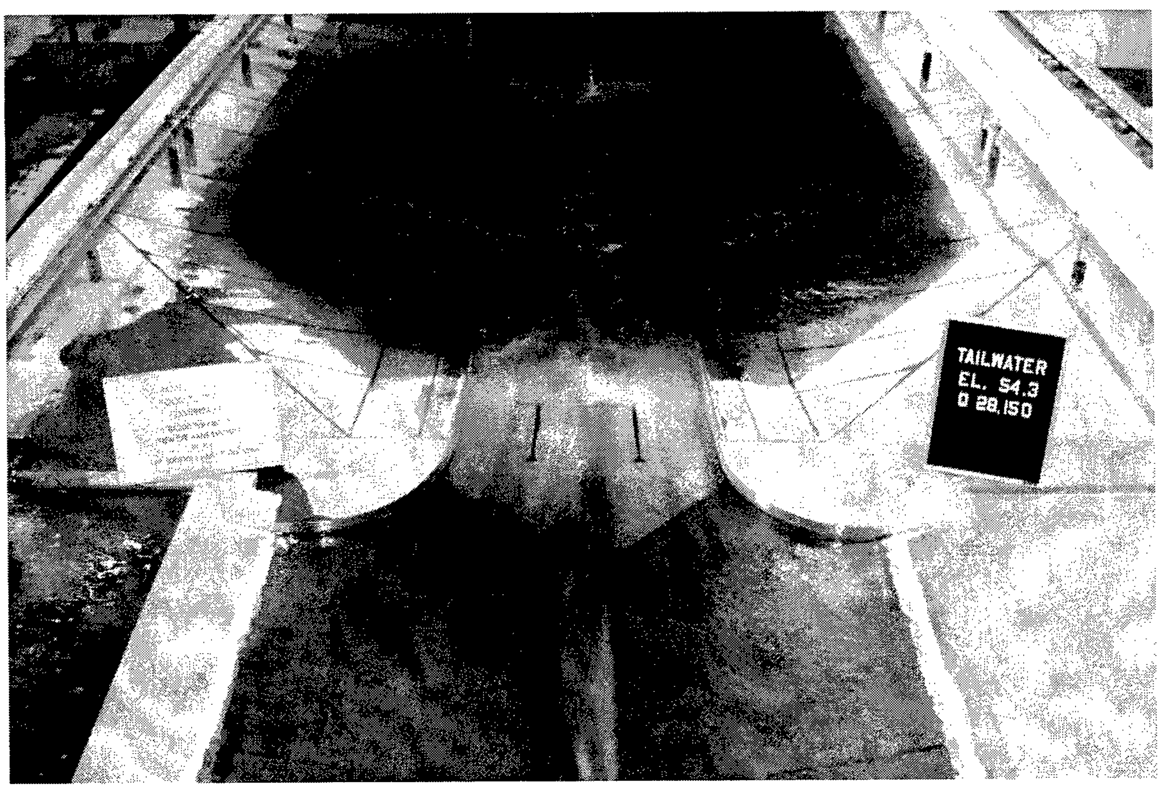


b. Tailwater el 52.9

Photo 2. Type 2 design weir and stilling basin with 10-yr discharge of 410.6 cu m/sec (14,500 cfs)

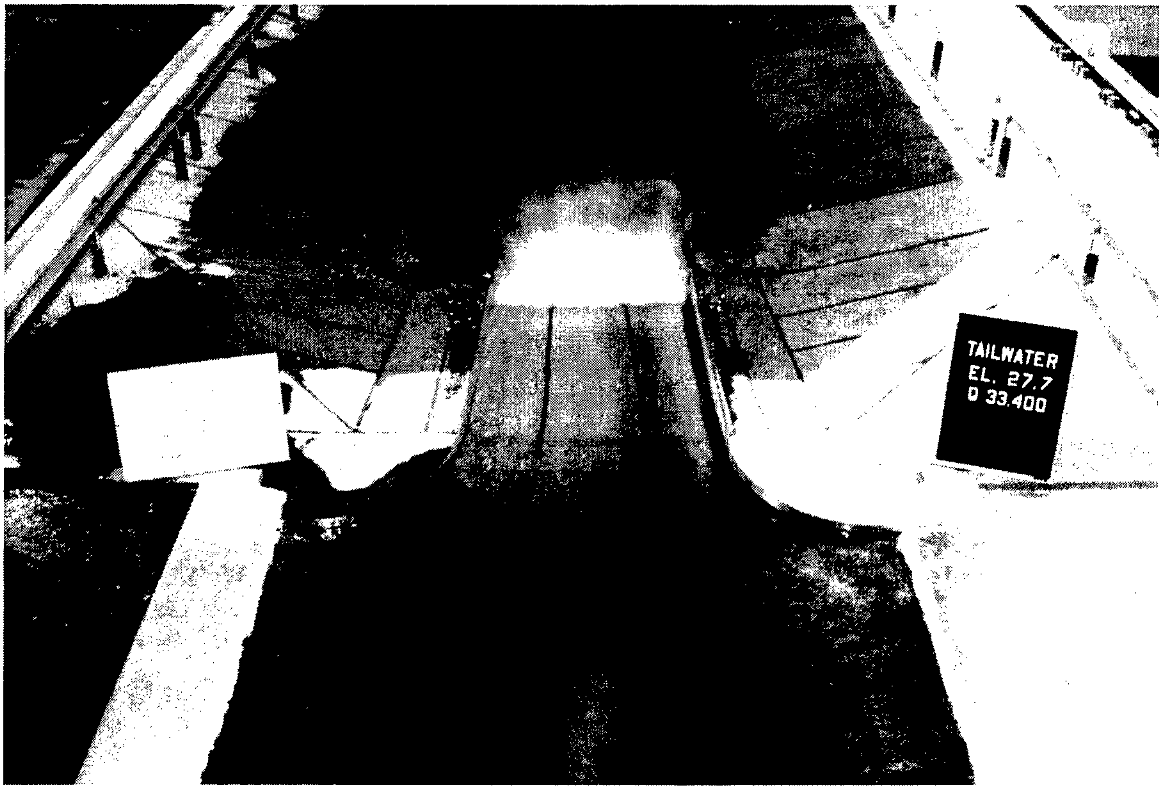


a. Tailwater el 26.0

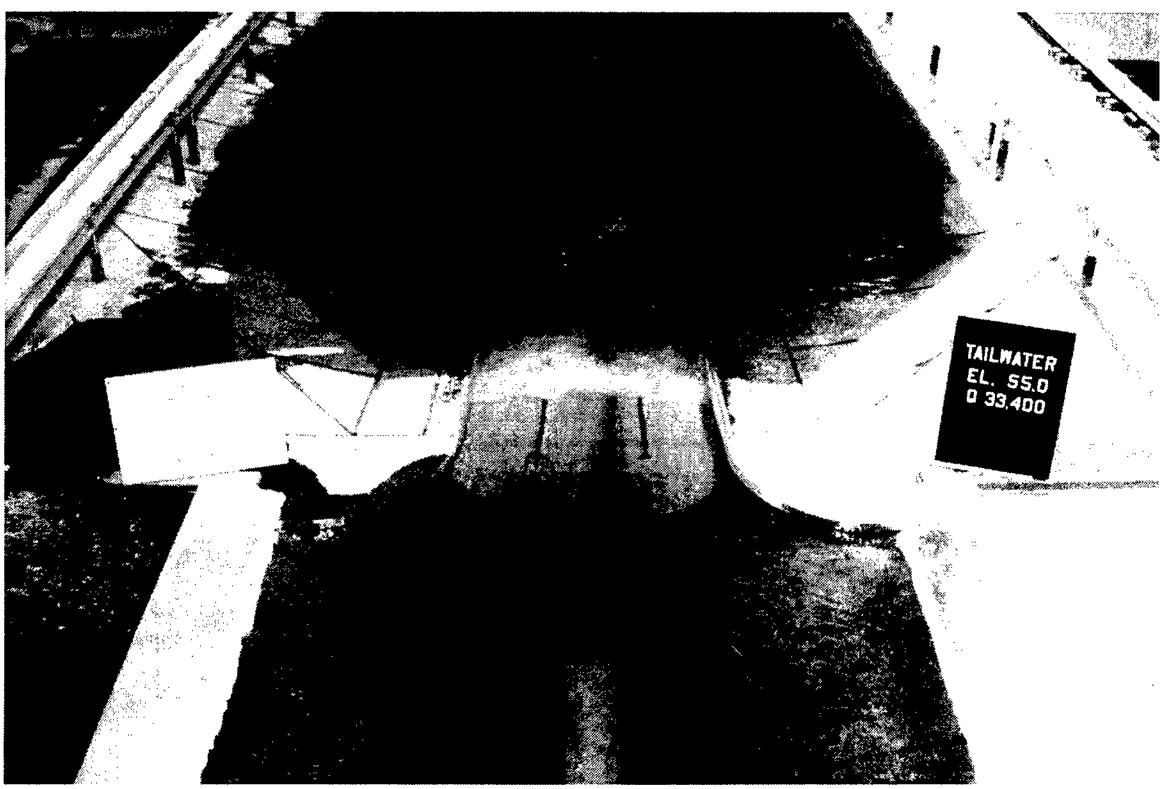


b. Tailwater el 54.3

Photo 3. Type 2 design weir and stilling basin with 100-yr discharge of 797.1 cu m/sec (28,150 cfs)

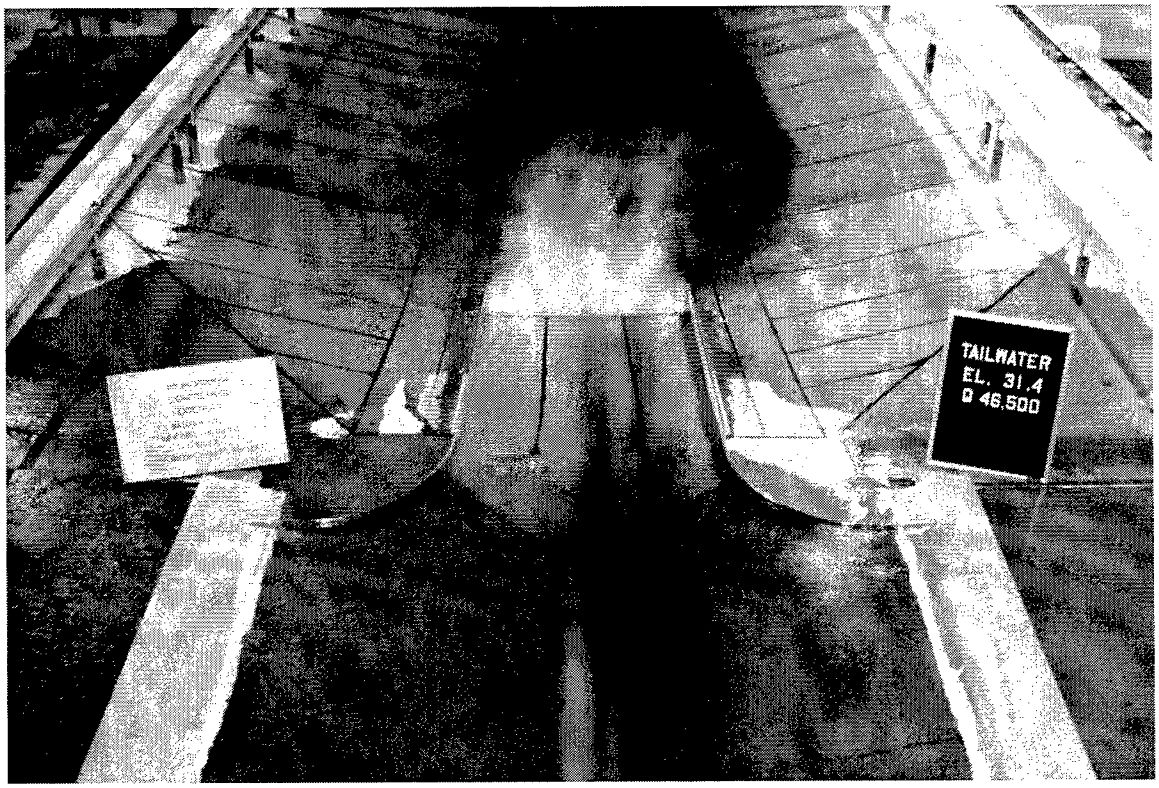


a. Tailwater el 27.7

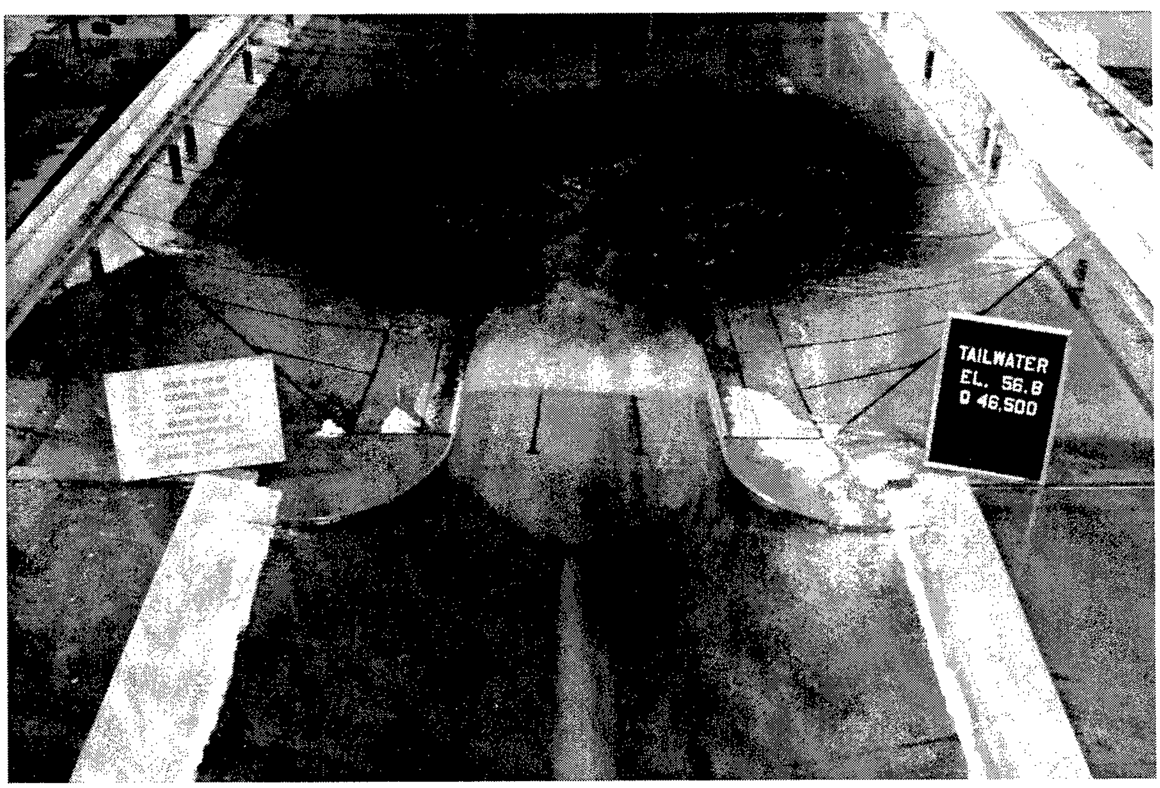


b. Tailwater el 55.0

Photo 4. Type 2 design weir and stilling basin with 500-yr discharge of 945.8 cu m/sec (33,400 cfs)

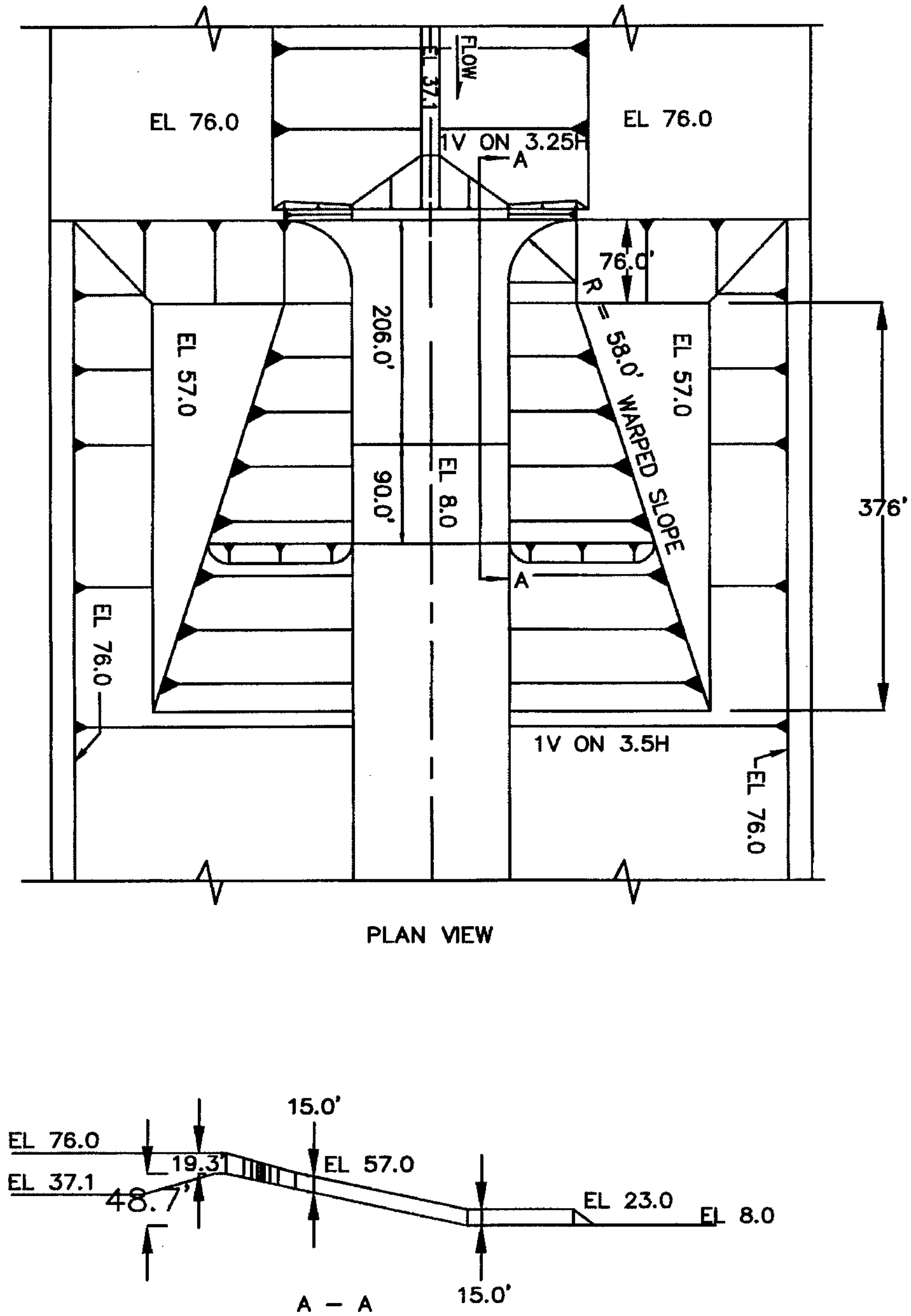


a. Tailwater el 31.4



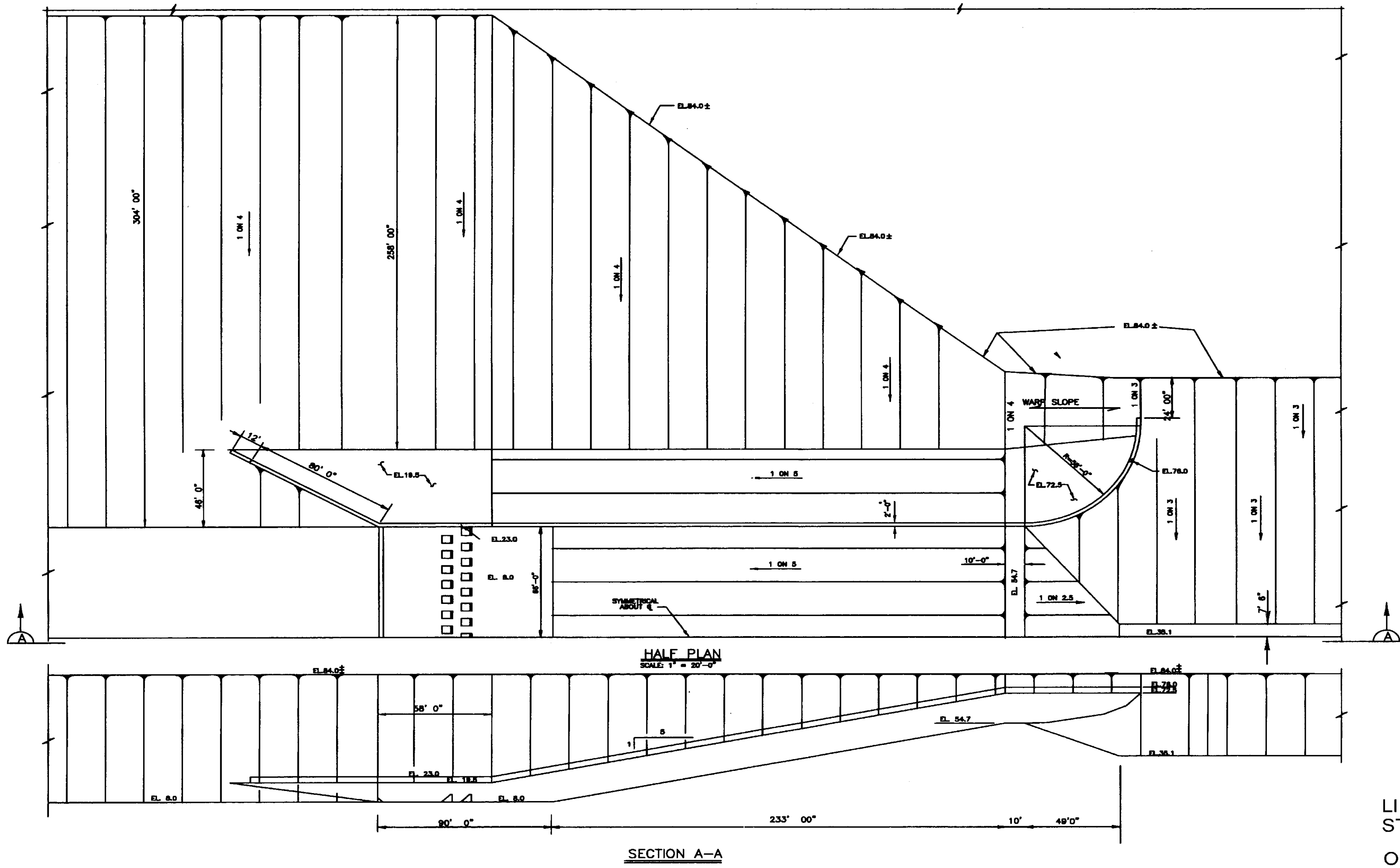
b. Tailwater el 56.8

Photo 5. Type 2 design weir and stilling basin with SPF-yr discharge of 1316.7 cu m/sec (46,500 cfs)



DIMENSIONS ARE IN PROTOTYPE FEET
(To convert to meters multiply by 0.3048)

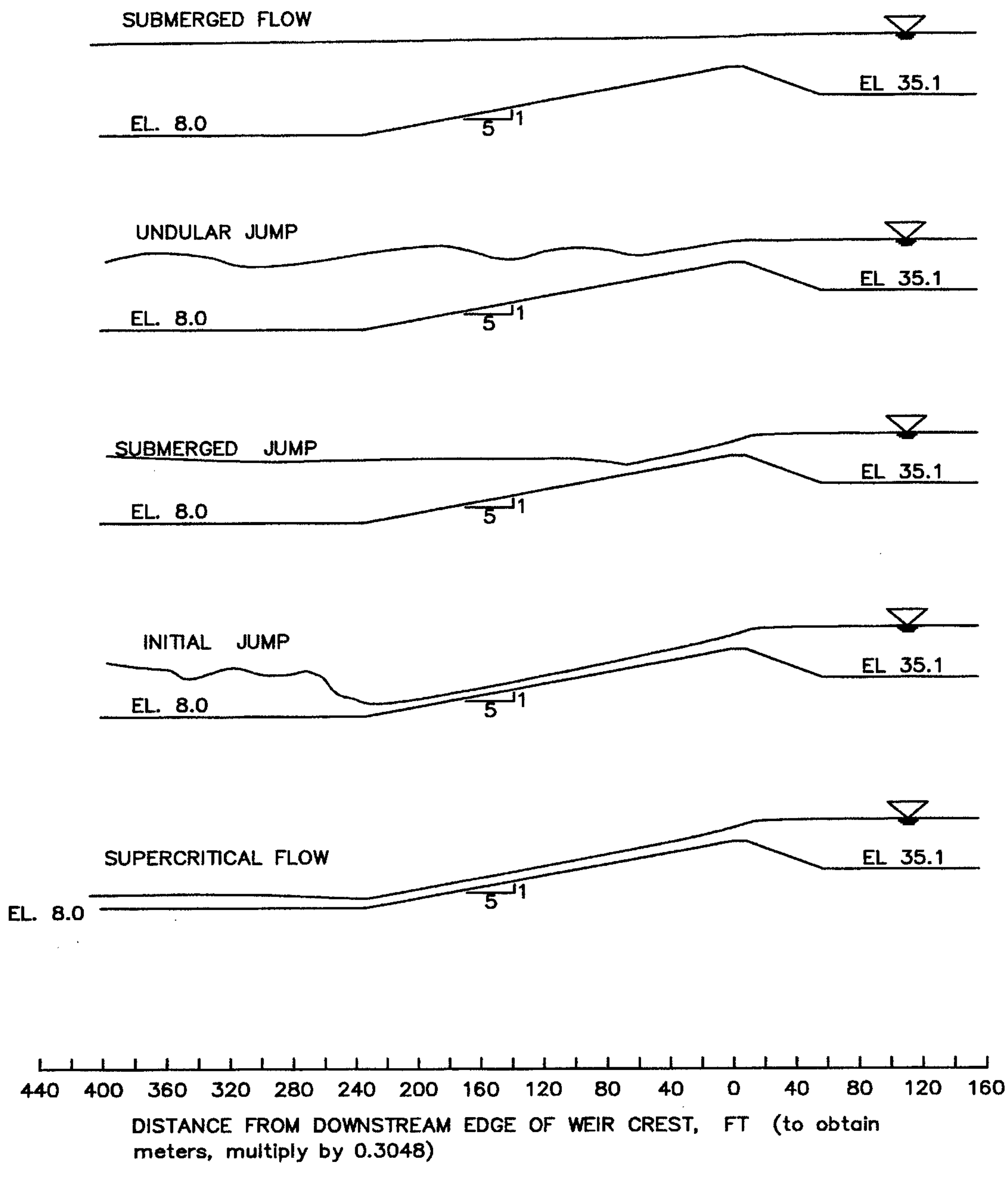
FINAL DESIGN FROM
1994 MODEL STUDY



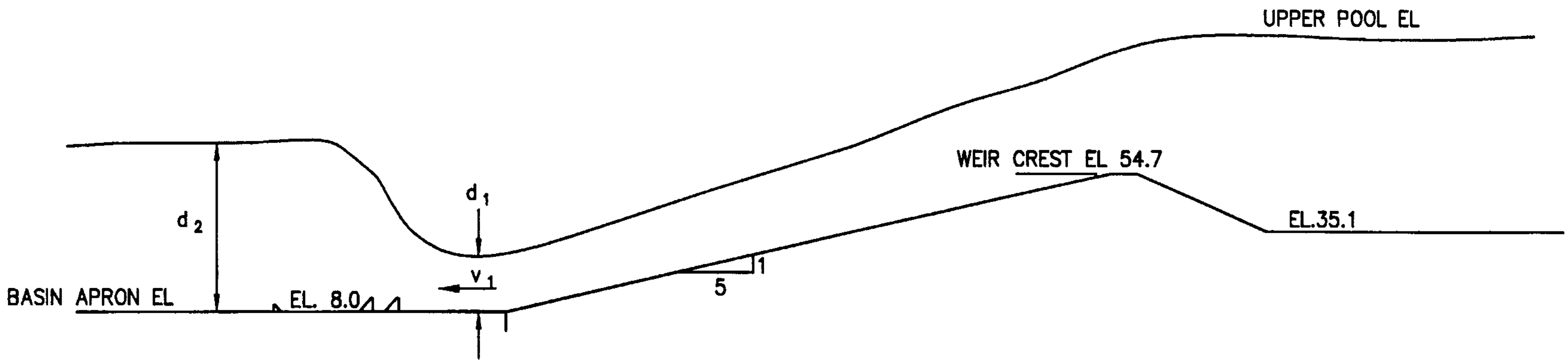
LILLY BAYOU
STRUCTURE

ORIGINAL
DESIGN

Plate 2



STILLING BASIN
HYDRAULIC CONDITIONS



SECTION THROUGH SPILLWAY AND STILLING BASIN

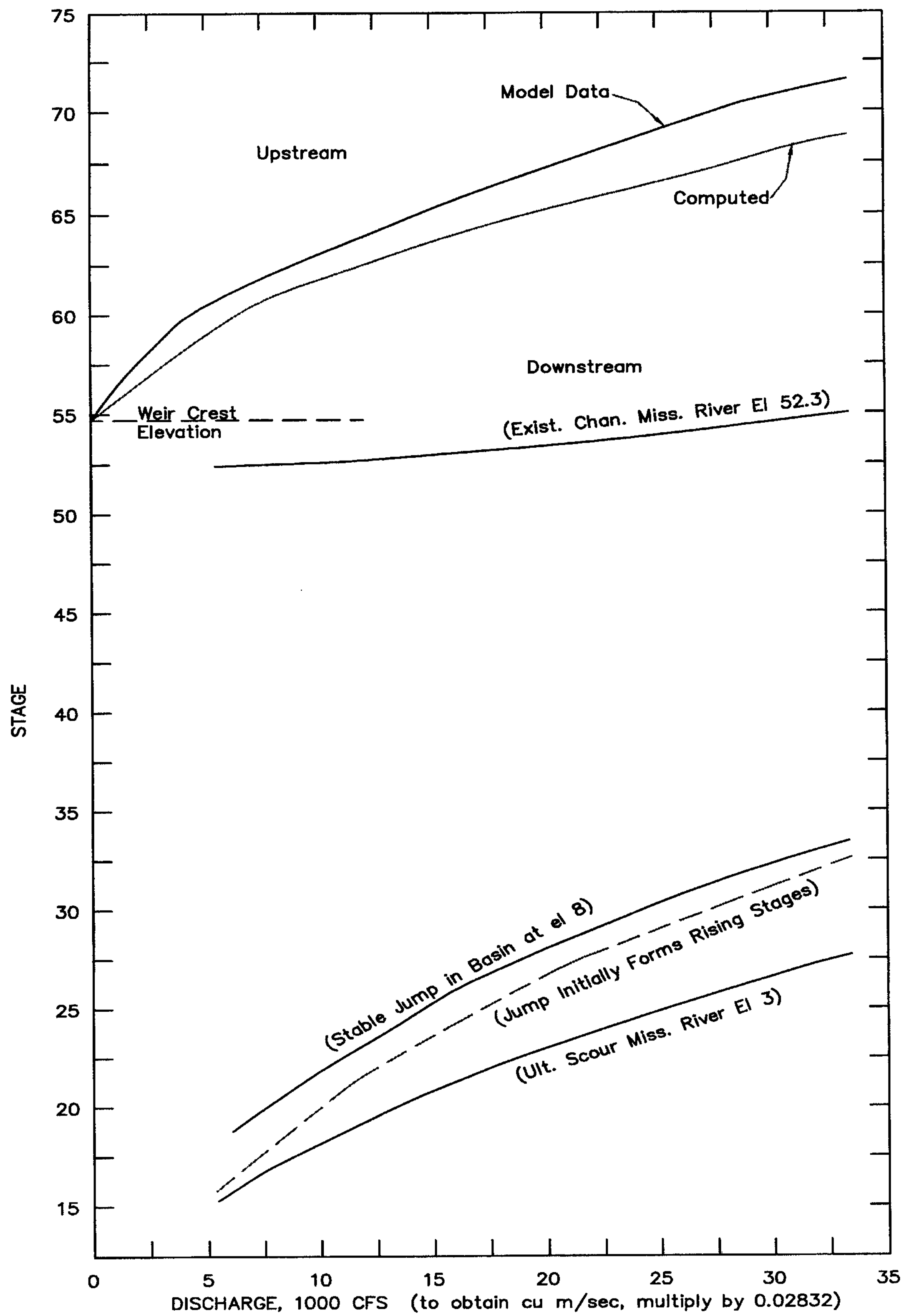
ENTERING FROUDE NO. $F_1 = \frac{v_1}{\sqrt{g d_1}}$

UNIT DISCHARGE $q_1 = v_1 d_1$

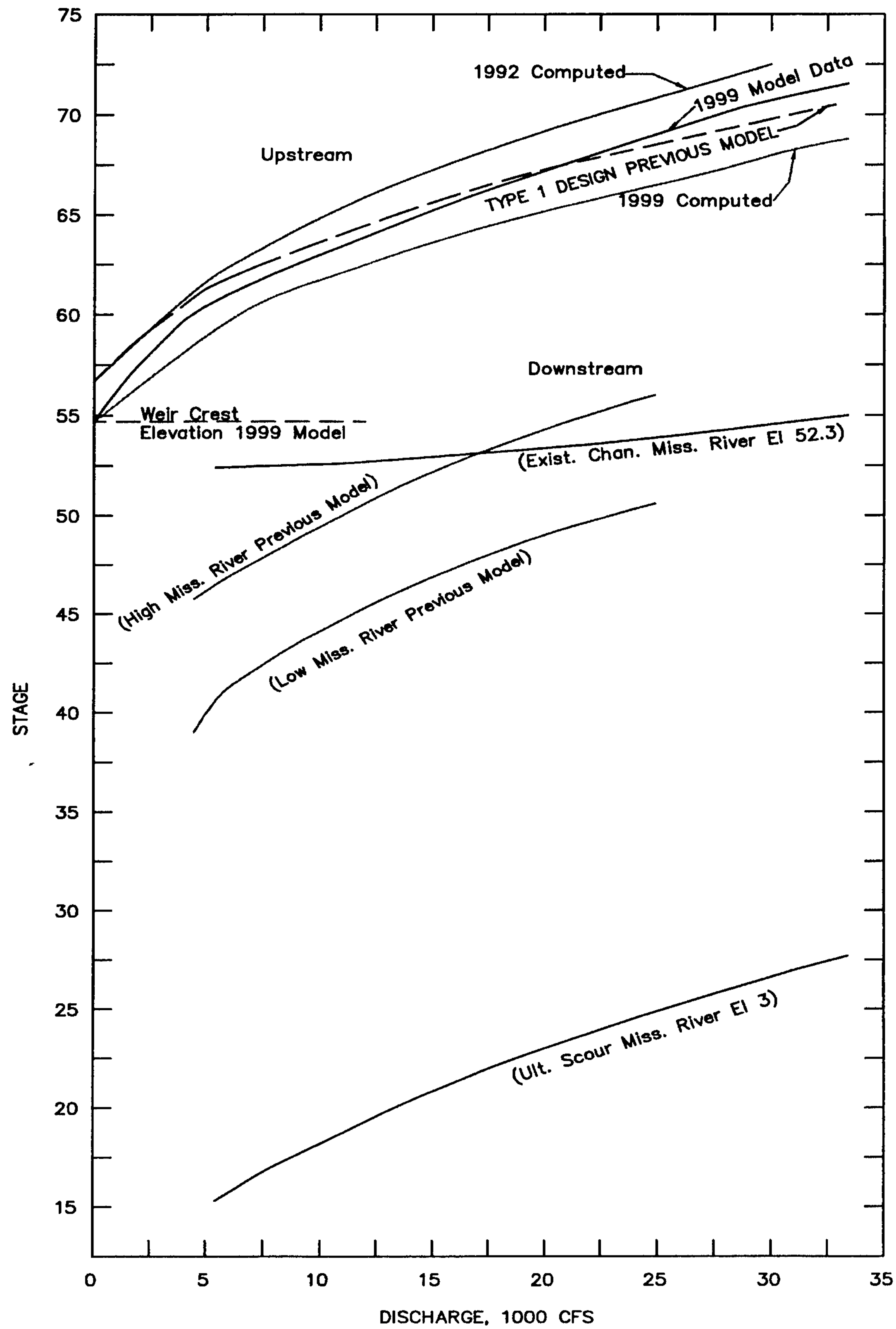
HYDRAULIC JUMP EQUATION

$$\frac{d_2}{d_1} = \frac{1}{2}\left(\sqrt{1 + 8 F_1^2} - 1\right)$$

HYDRAULIC PARAMETERS FOR SPILLWAY AND STILLING BASIN

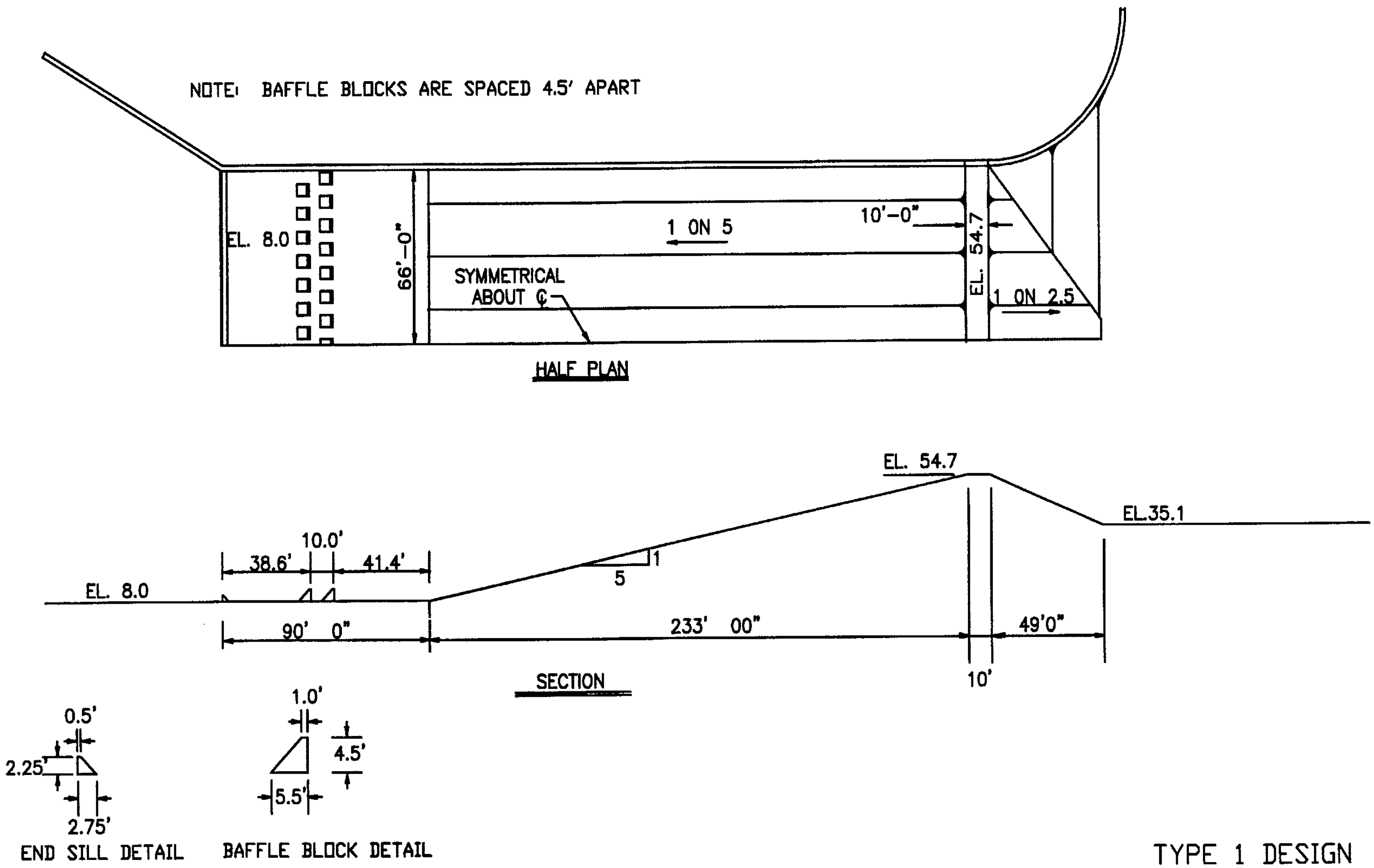


RATING CURVES
ORIGINAL DESIGN, NO BAFFLE BLOCKS

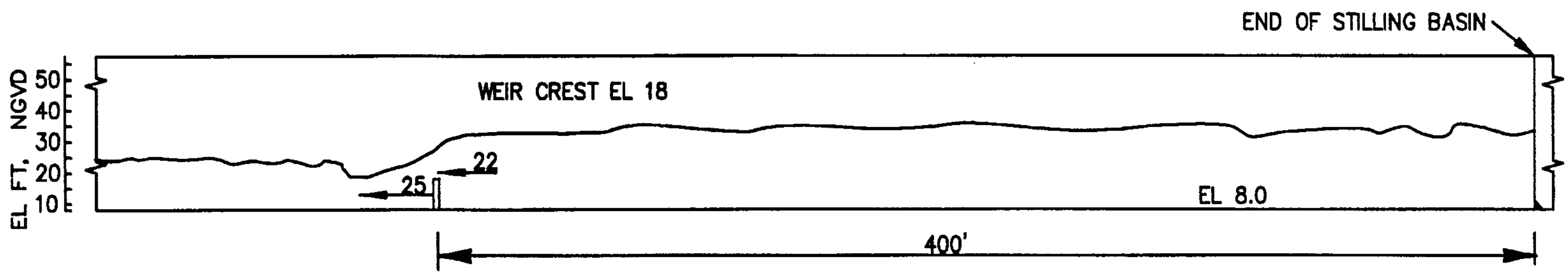


COMPARISON OF RATING CURVES

Plate 6

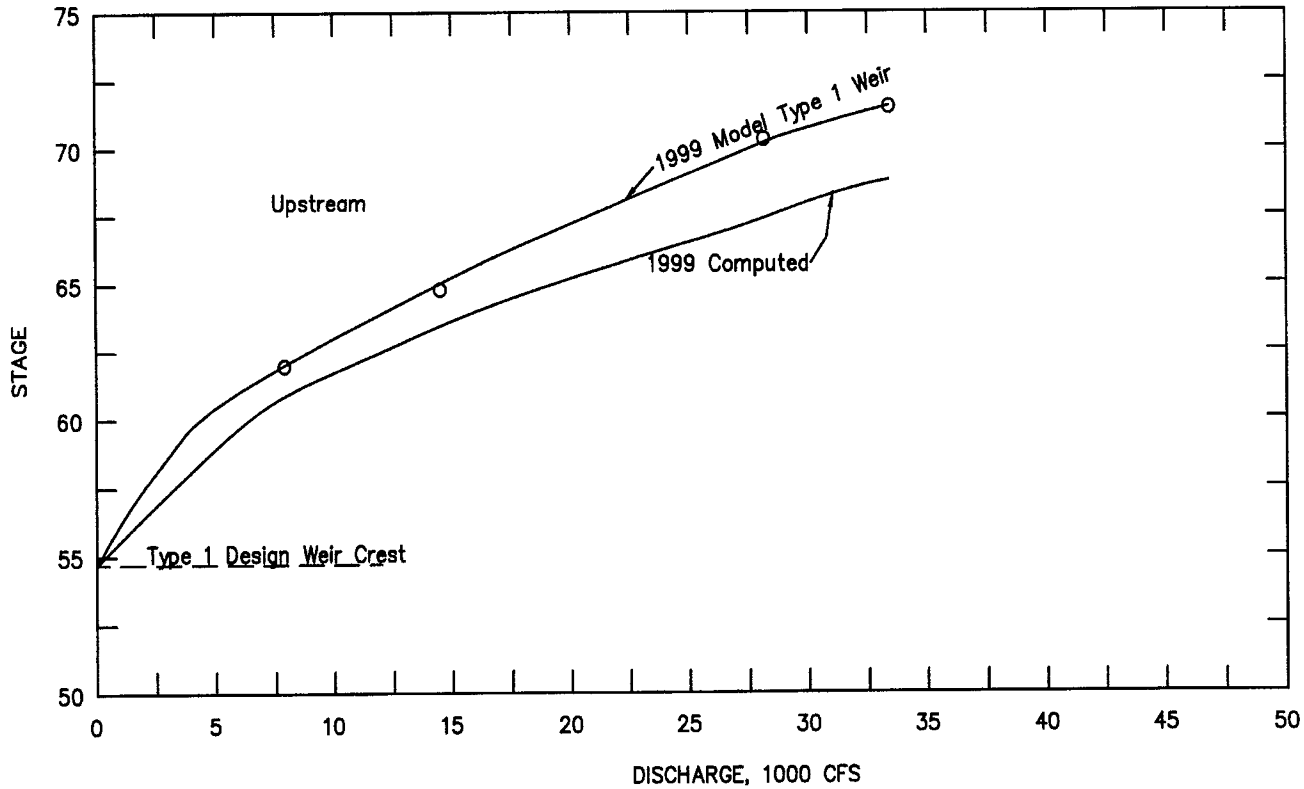


TYPE 1 DESIGN
SPILLWAY AND
STILLING BASIN
DETAILS



NOTE: VELOCITIES ARE IN FT/SEC

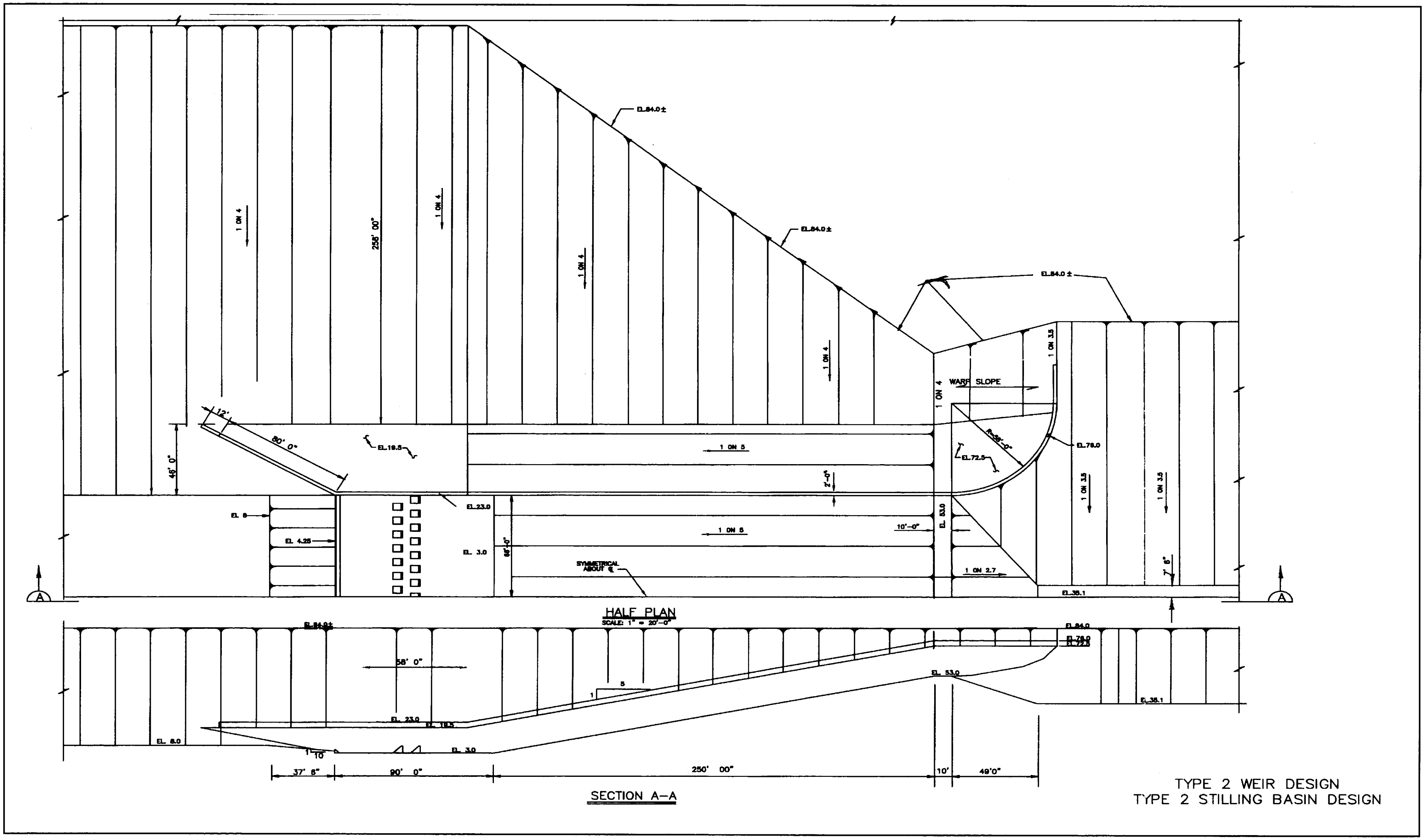
WEIR IN EXIT CHANNEL
DISCHARGE 33,400 CFS

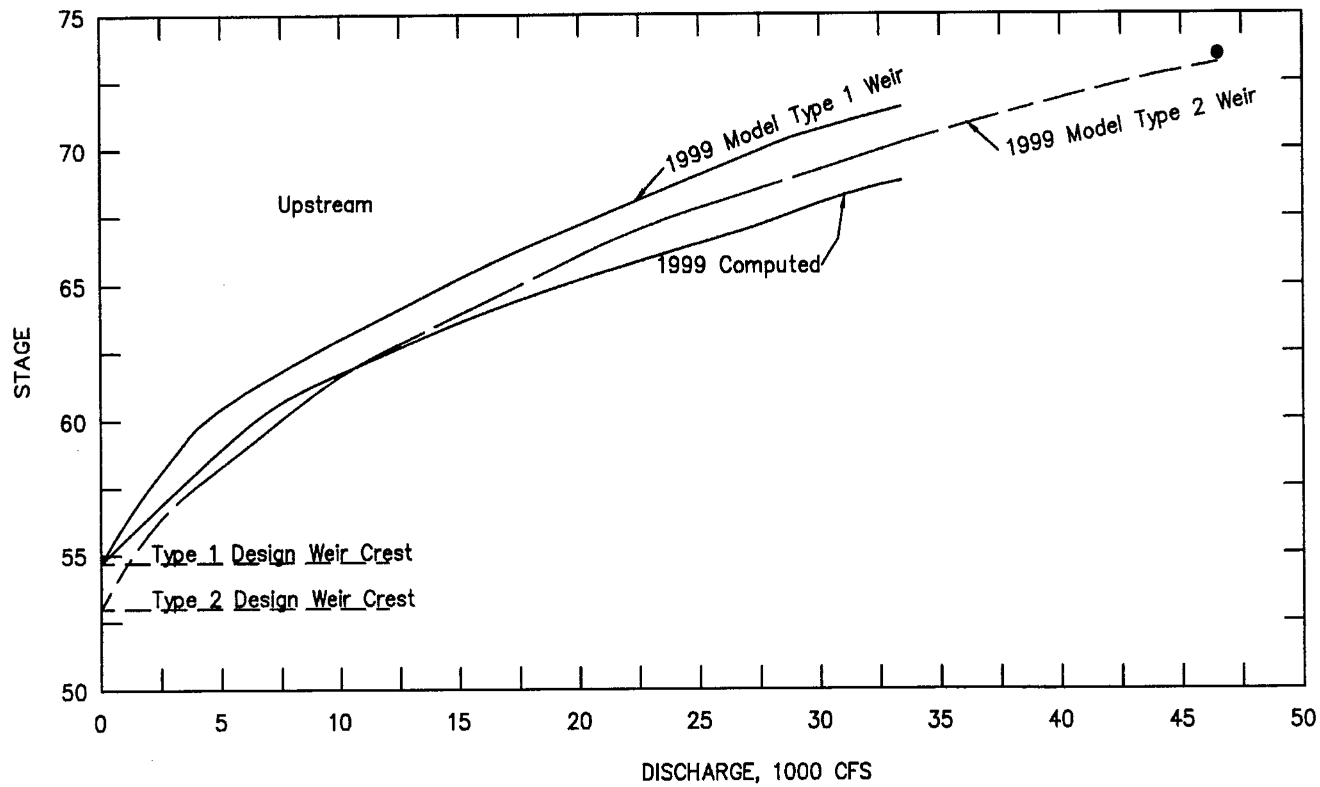


○ STAGES WITH 1V ON 3.5H SIDE SLOPES

2-YR DISCHARGE = 7,890 CFS
10-YR DISCHARGE = 14,500 CFS
100-YR DISCHARGE = 28,150 CFS
500-YR DISCHARGE = 33,400 CFS

UPSTREAM STAGES WITH
1V ON 3.5H APPROACH CHANNEL
SIDE SLOPES

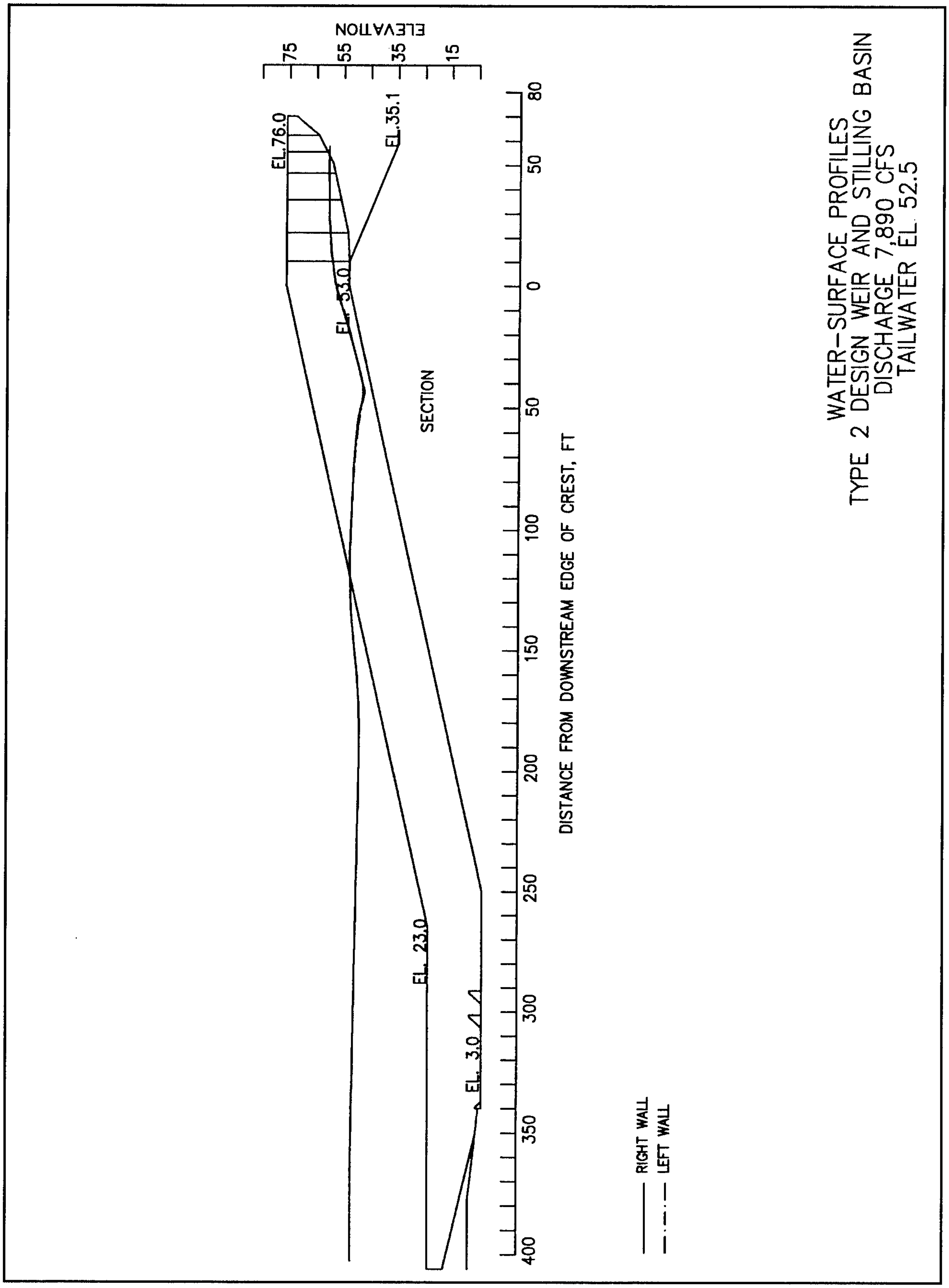

HALF PLAN
SCALE: 1" = 20'-0"
SECTION A-A
258' 00"
45' 0"
80' 0"
12'
1 ON 4
1 ON 5
1 ON 3.5
1 ON 2.7
WARP SLOPE
SYMMETRICAL ABOUT ℄
EL 84.0 ±
EL 78.0
EL 72.5
EL 53.0
EL 35.1
EL 23.0
EL 19.5
EL 3.0
EL 4.25
EL 8.0
58' 0"
37' 6"
90' 0"
250' 00"
10'
49'0"
TYPE 2 WEIR DESIGN
TYPE 2 STILLING BASIN DESIGN



● HIGH TAILWATER

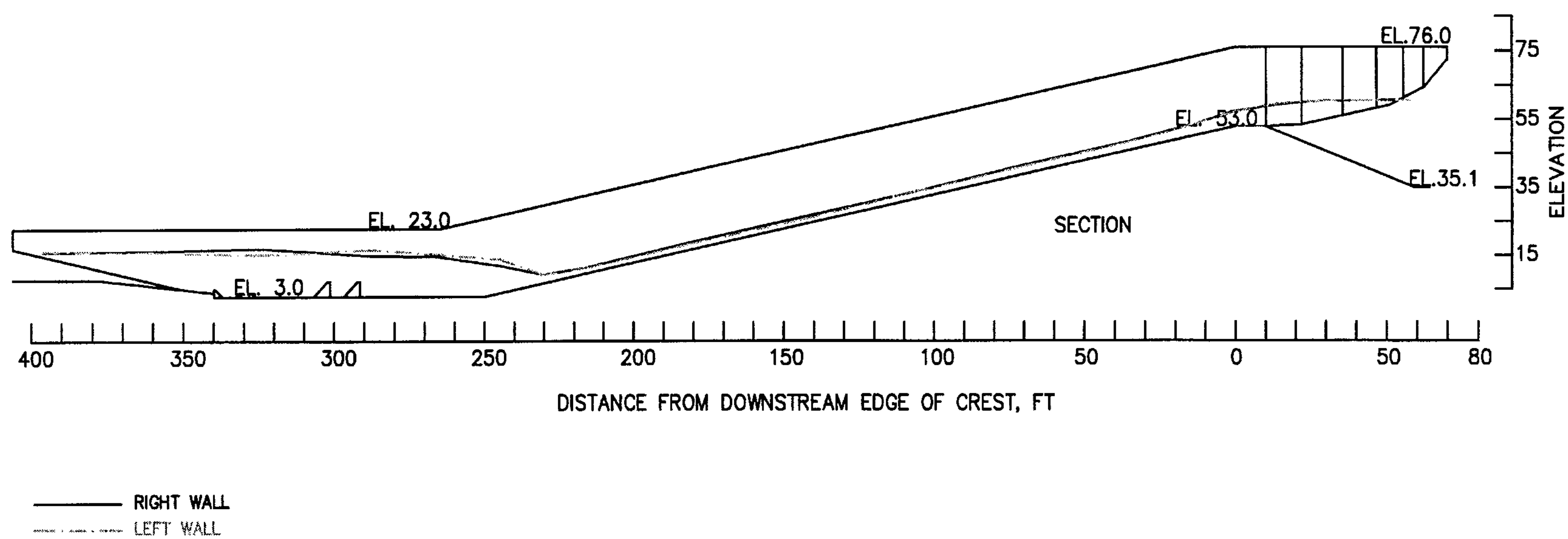
2-YR DISCHARGE = 7,890 CFS
10-YR DISCHARGE = 14,500 CFS
100-YR DISCHARGE = 28,150 CFS
500-YR DISCHARGE = 33,400 CFS

UPSTREAM STAGES WITH
AND TYPE 2 WEIR

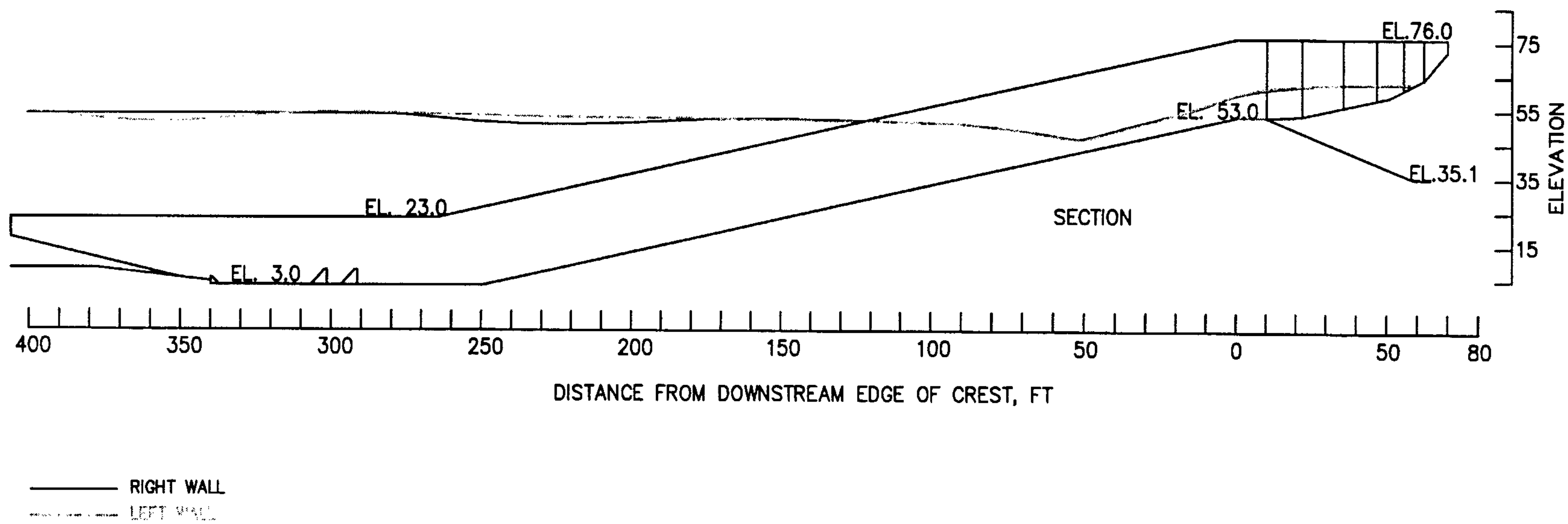


WATER-SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 7,890 CFS
TAILWATER EL 52.5

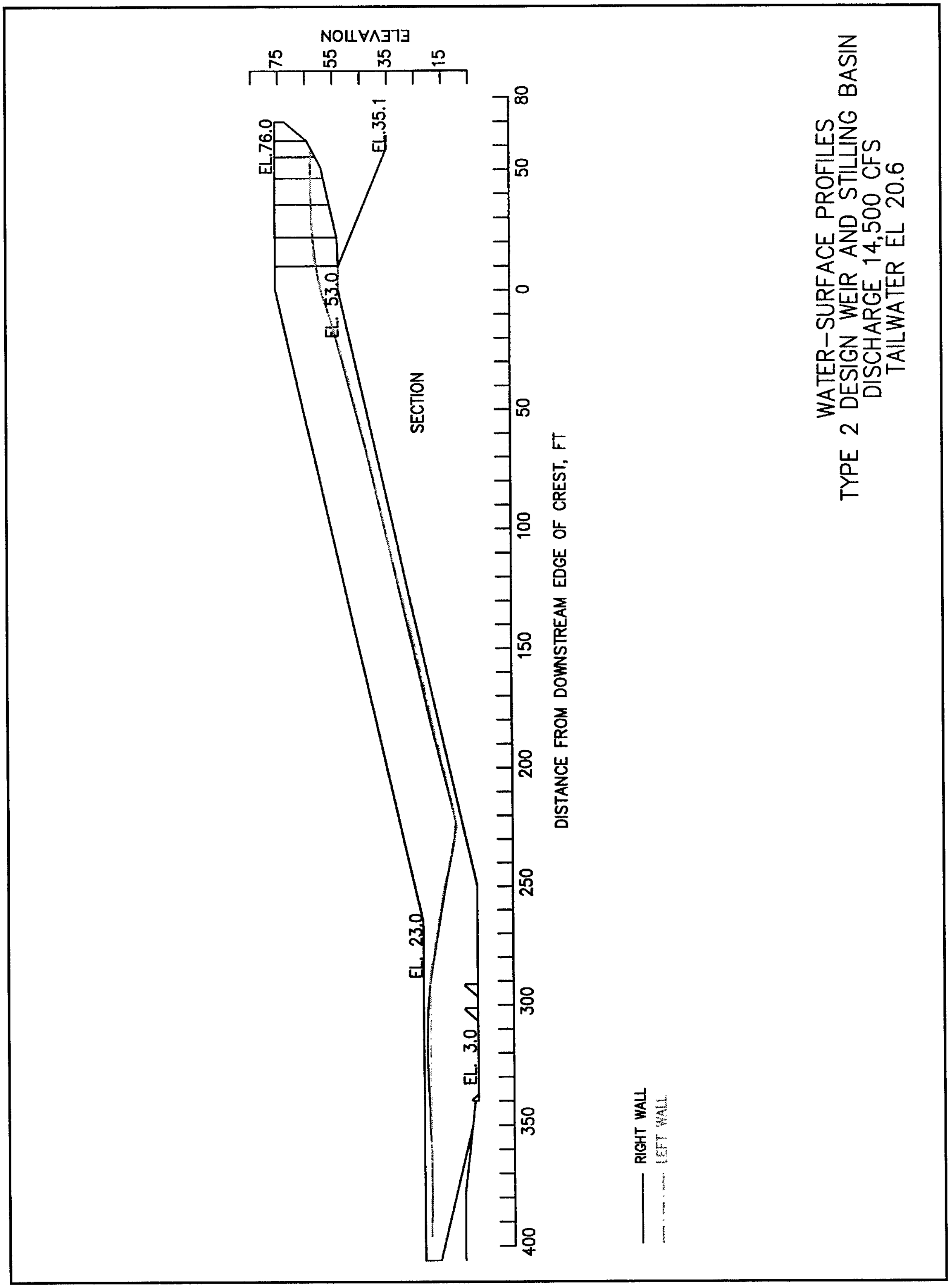
Plate 12



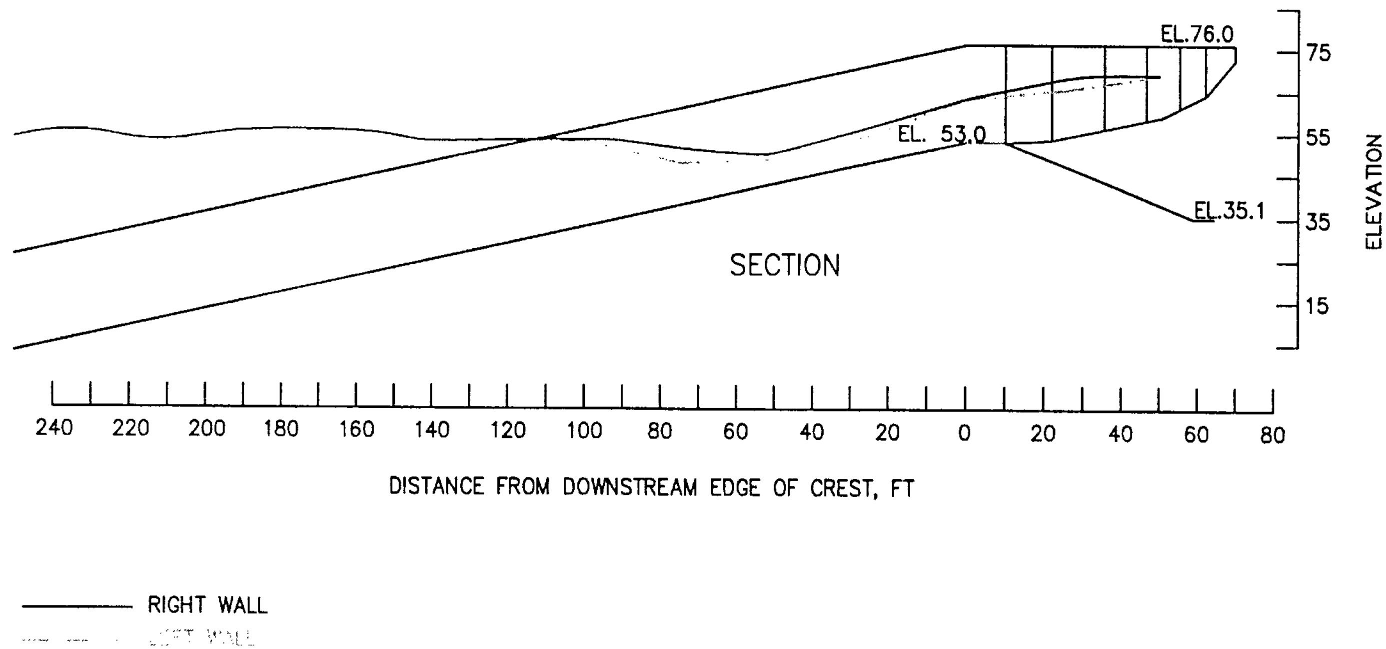
WATER-SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 7,890 CFS
TAILWATER EL 17.0



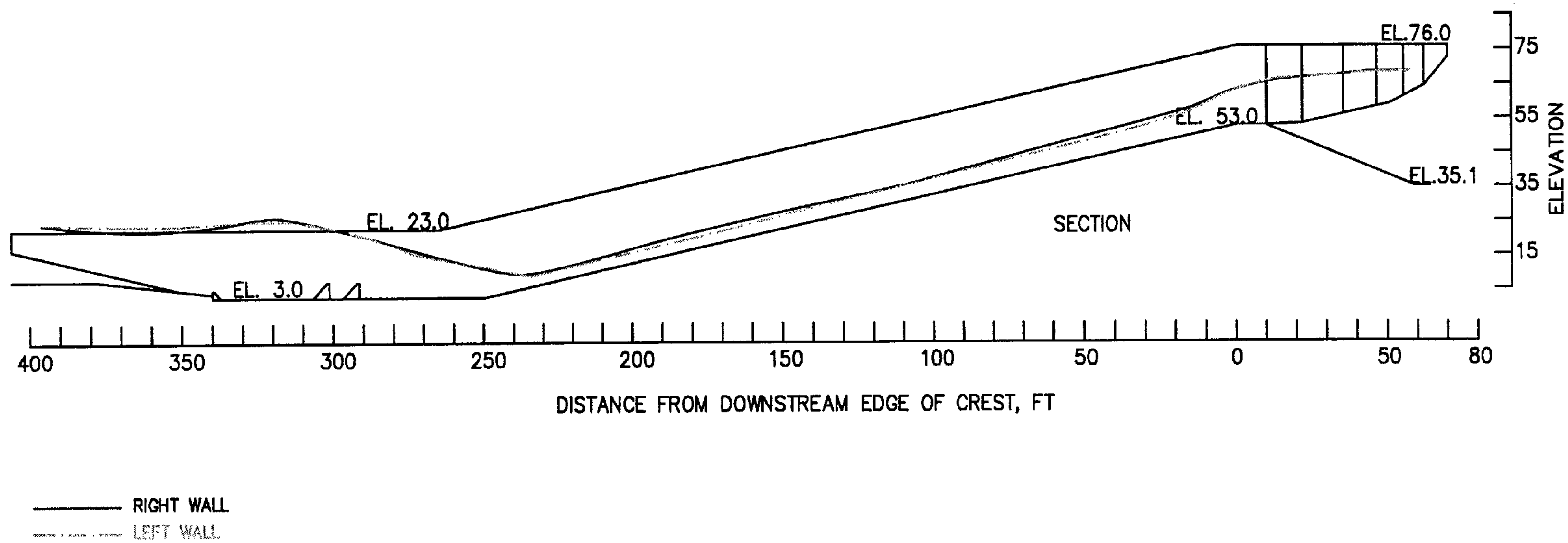
WATER–SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 14,500 CFS
TAILWATER EL 52.9



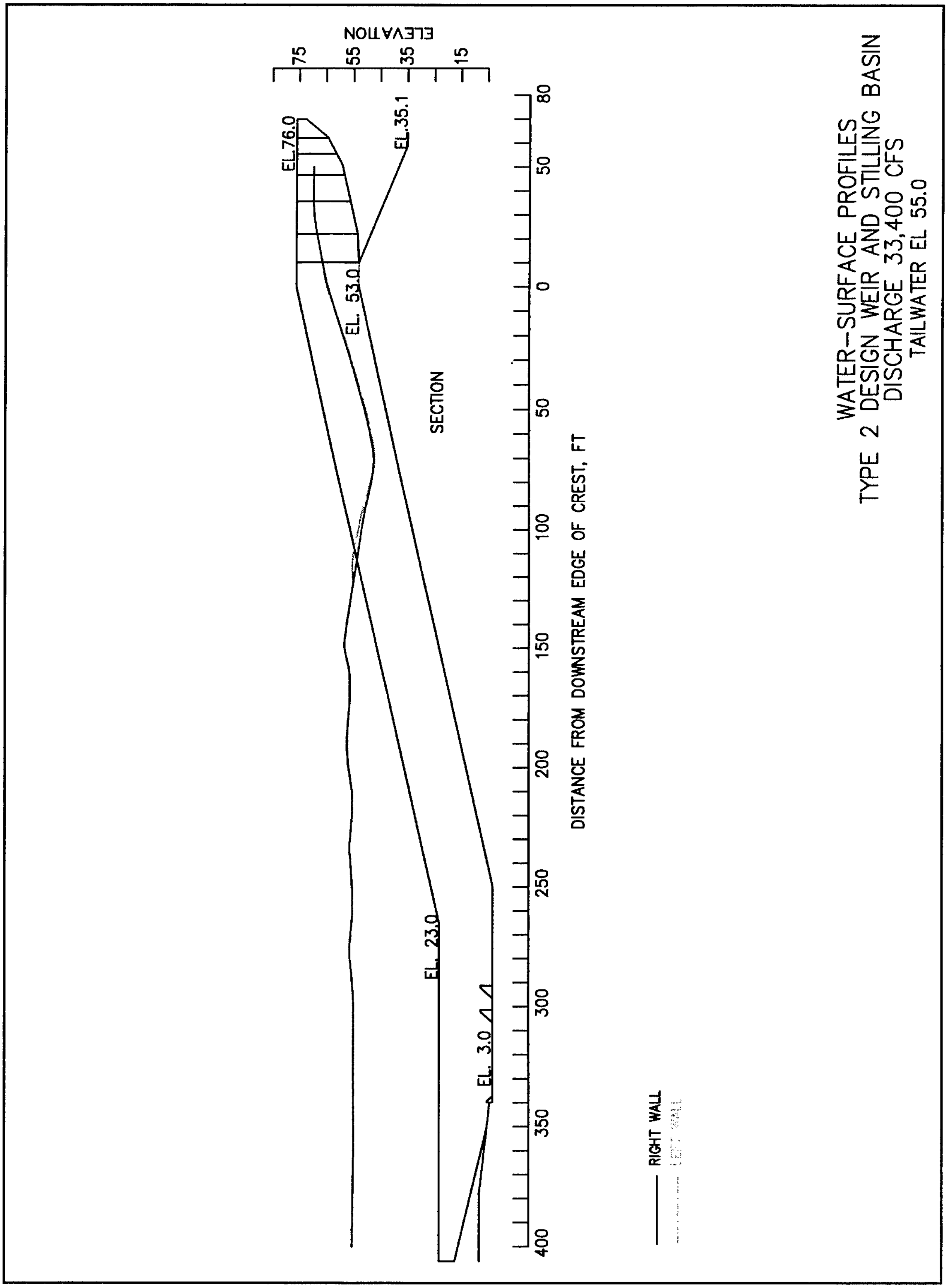
WATER-SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 14,500 CFS
TAILWATER EL 20.6



WATER-SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 28,150 CFS
TAILWATER EL 54.3

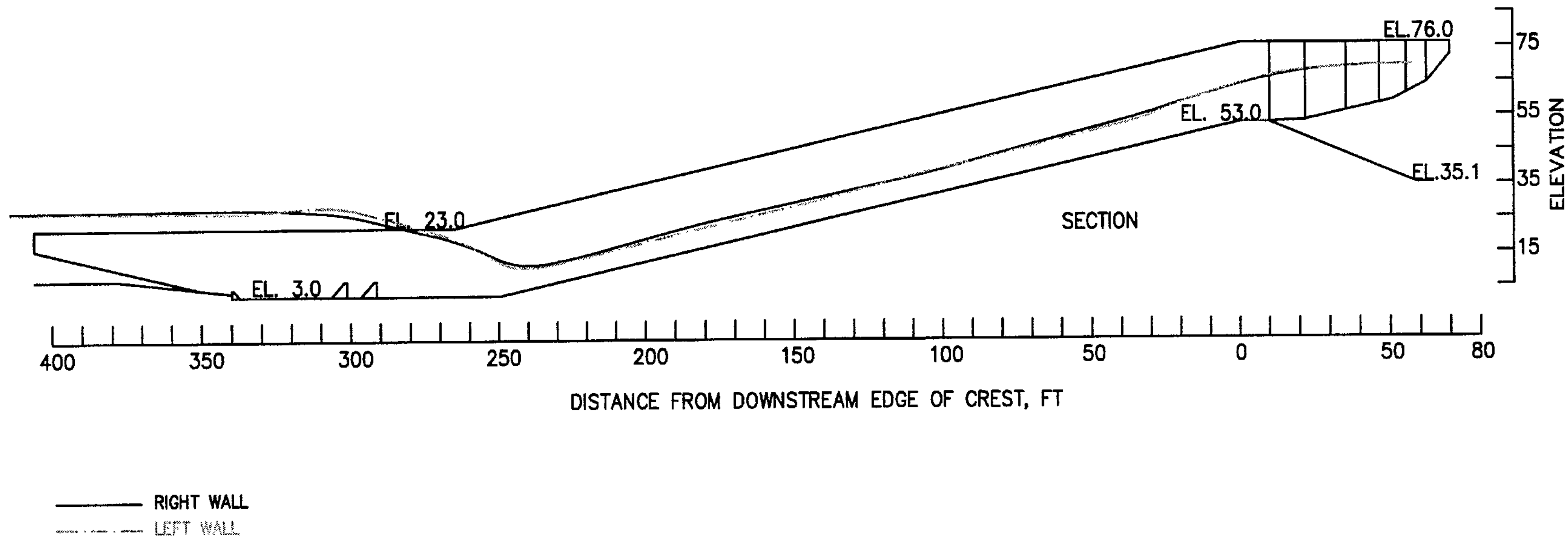


WATER–SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 28,150 CFS
TAILWATER EL 26.0

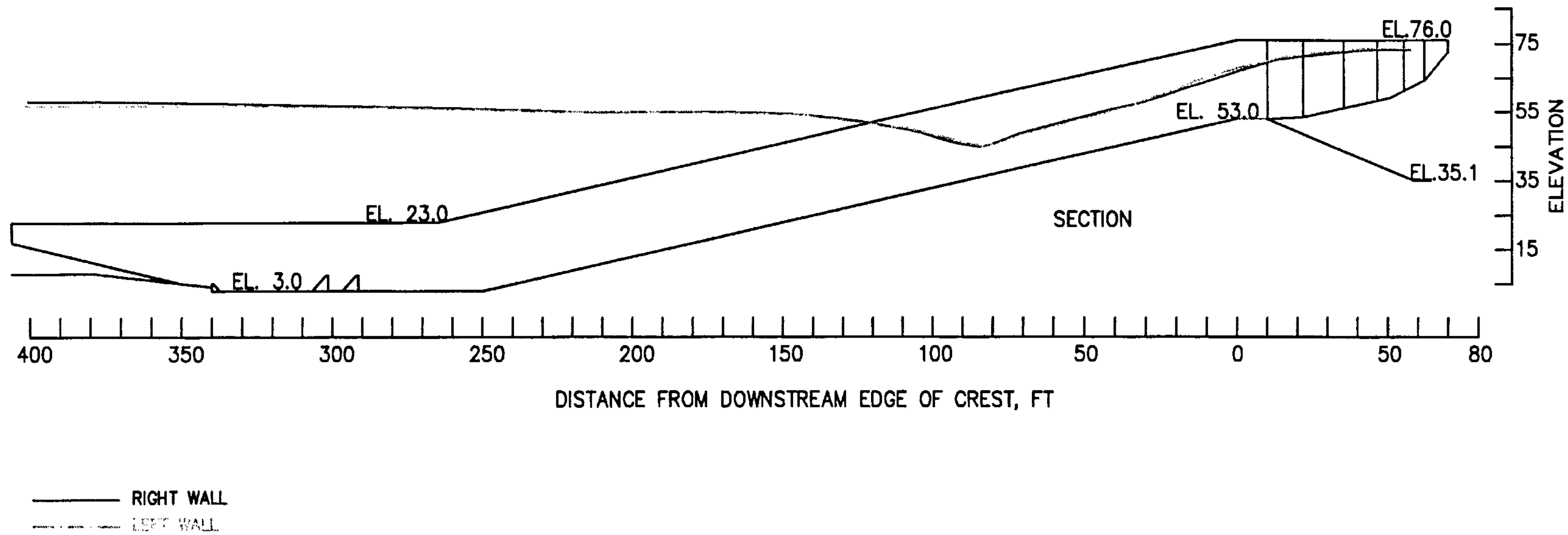


WATER–SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 33,400 CFS
TAILWATER EL 55.0

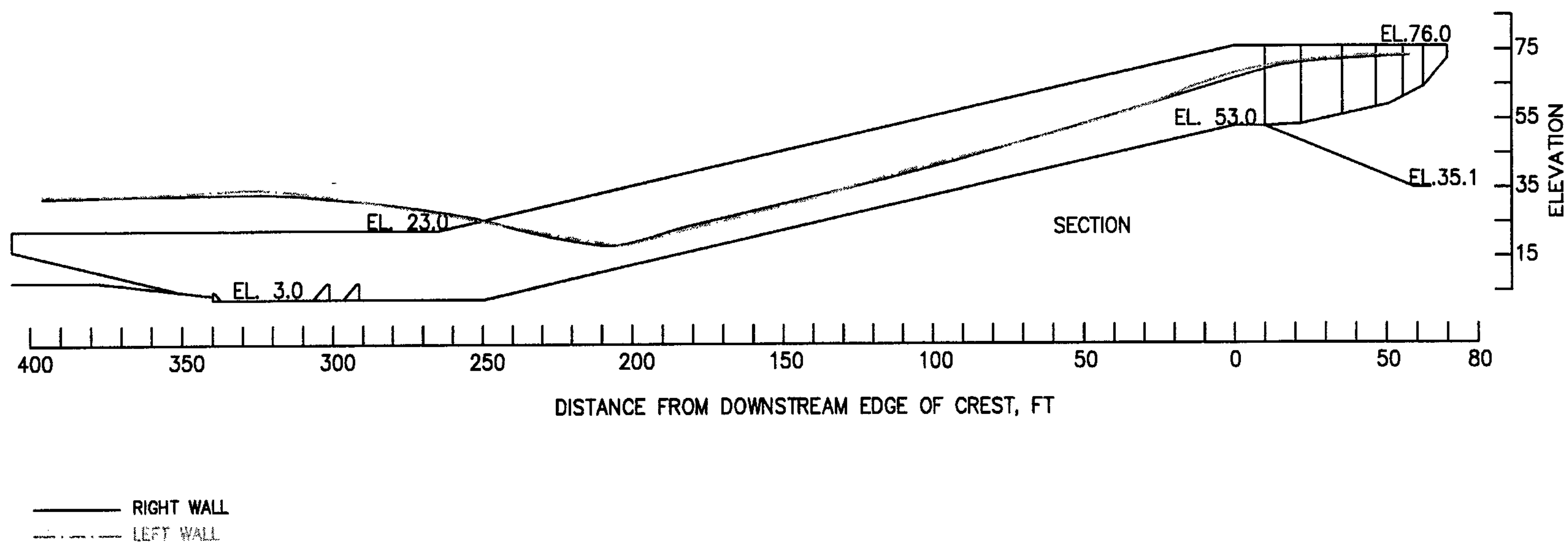
Plate 18



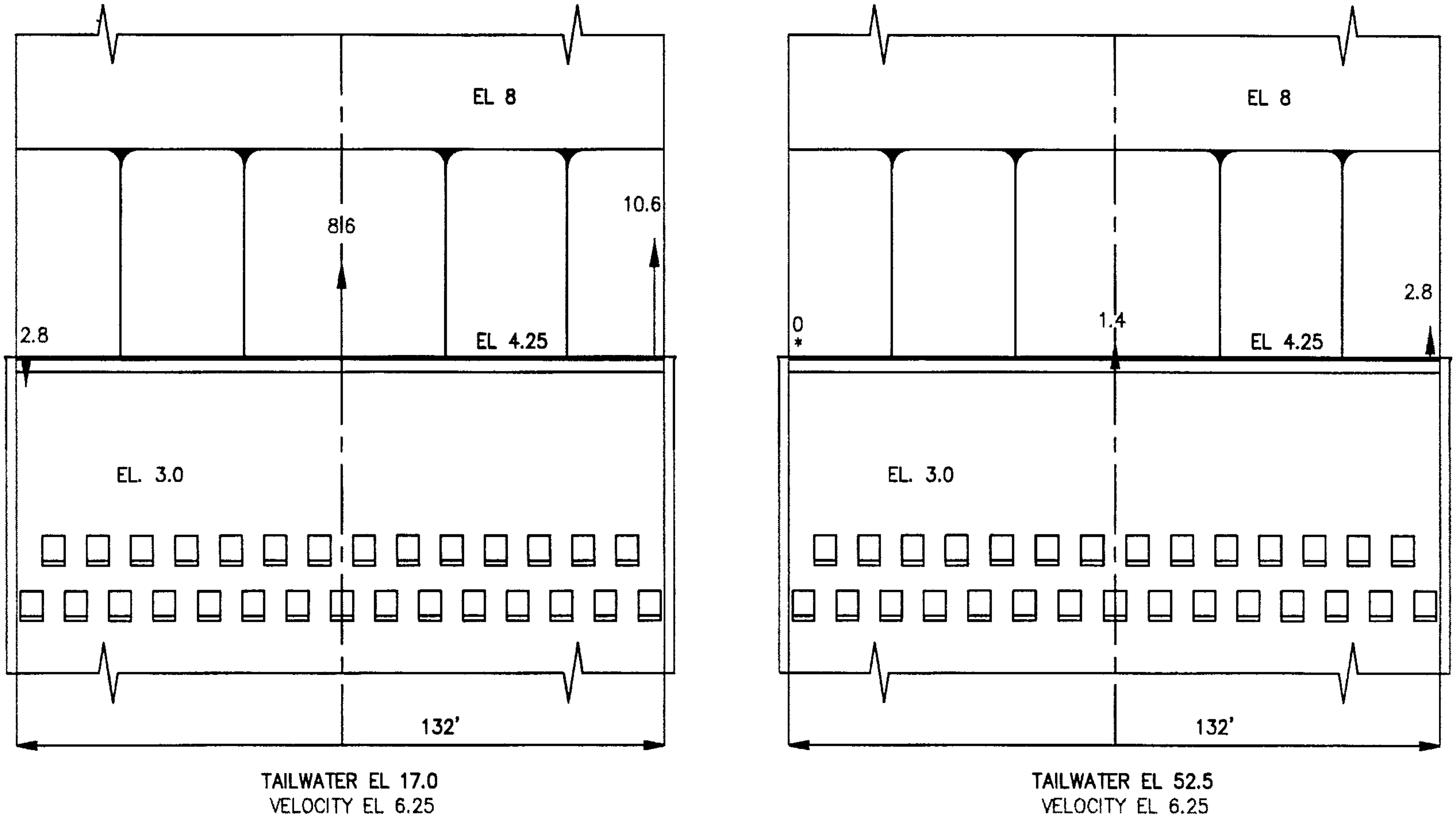
WATER-SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 33,400 CFS
TAILWATER EL 27.7



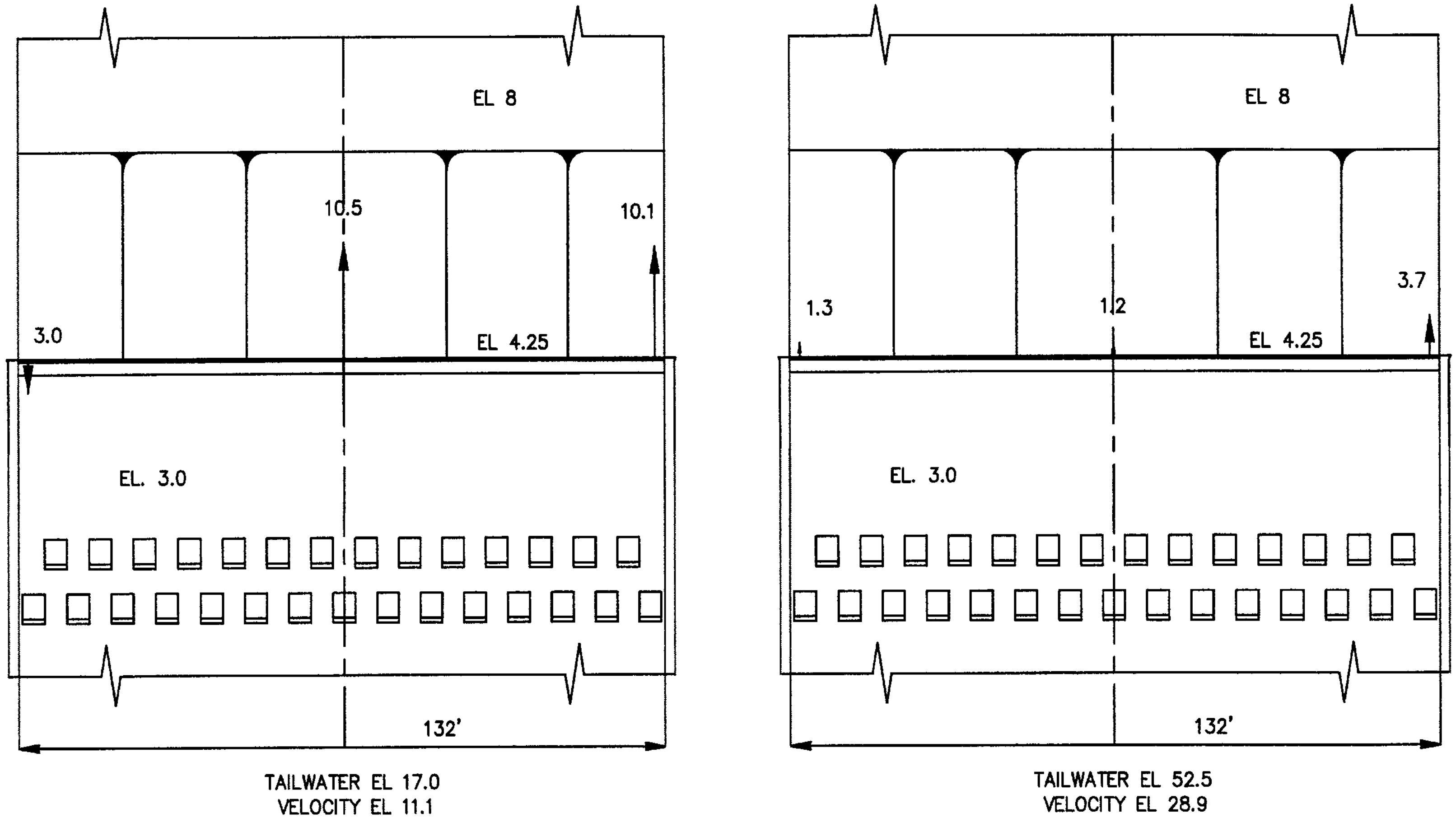
WATER–SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 46,500 CFS
TAILWATER EL 56.8



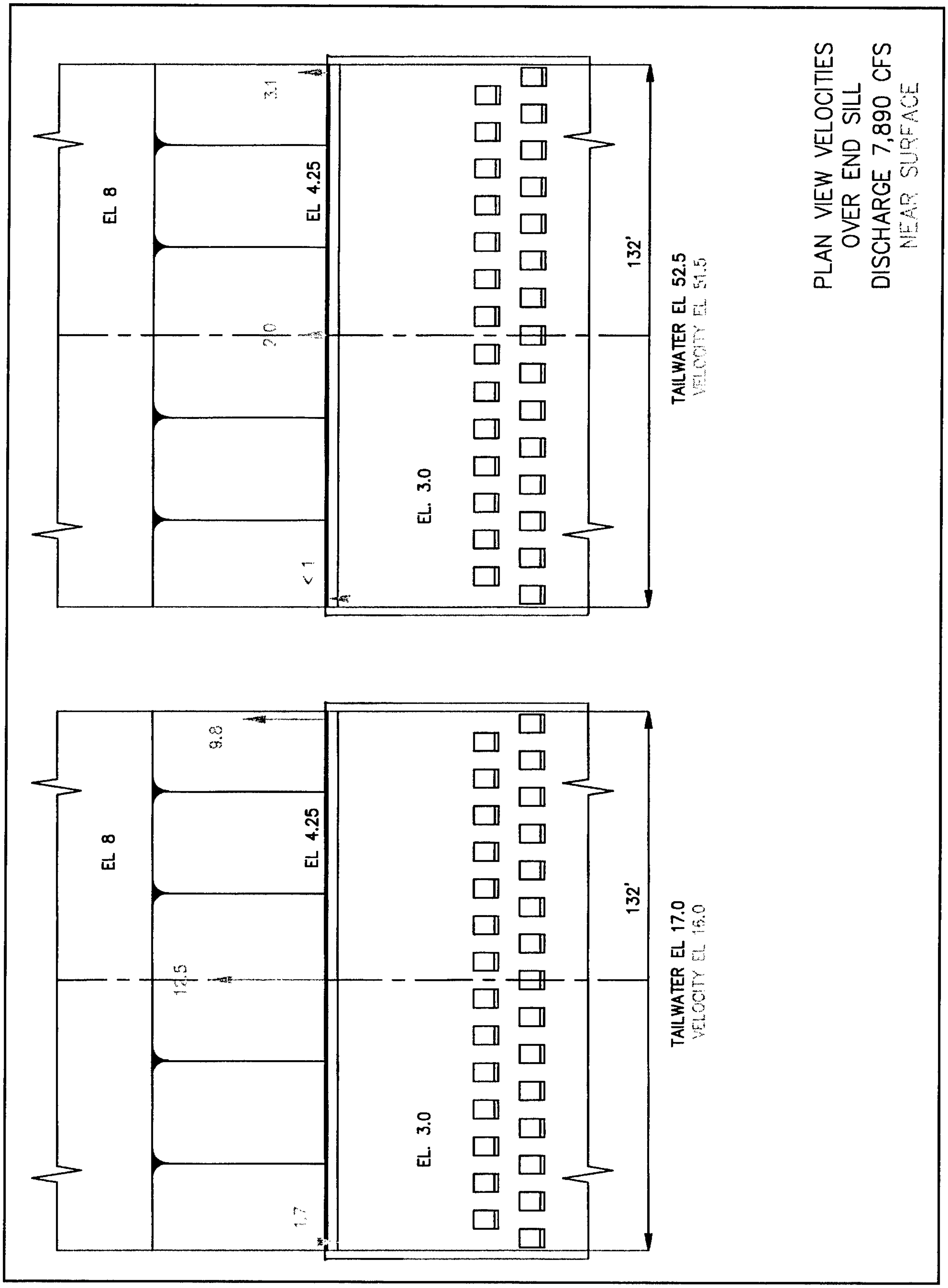
WATER-SURFACE PROFILES
TYPE 2 DESIGN WEIR AND STILLING BASIN
DISCHARGE 46,500 CFS
TAILWATER EL 31.4



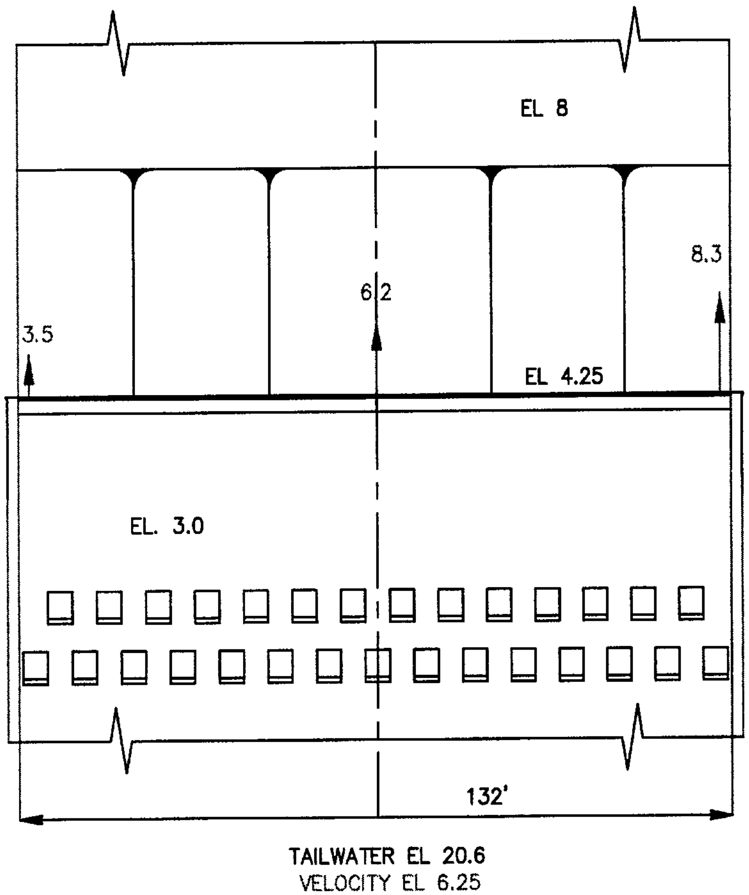
PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 7,890 CFS
1 FT ABOVE END SILL

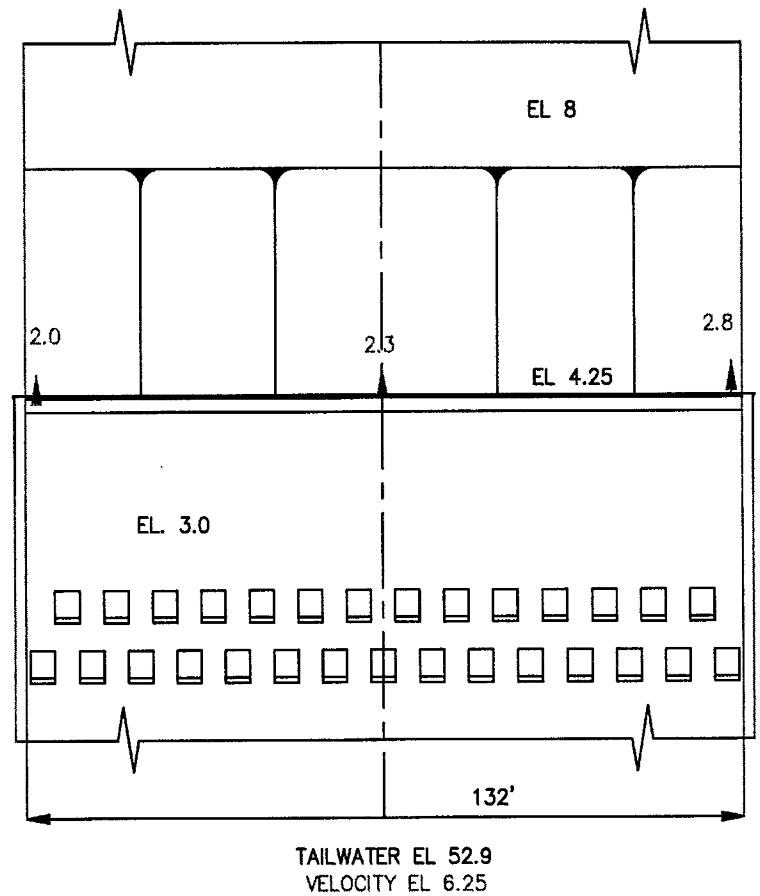


PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 7,890 CFS
MID DEPTH

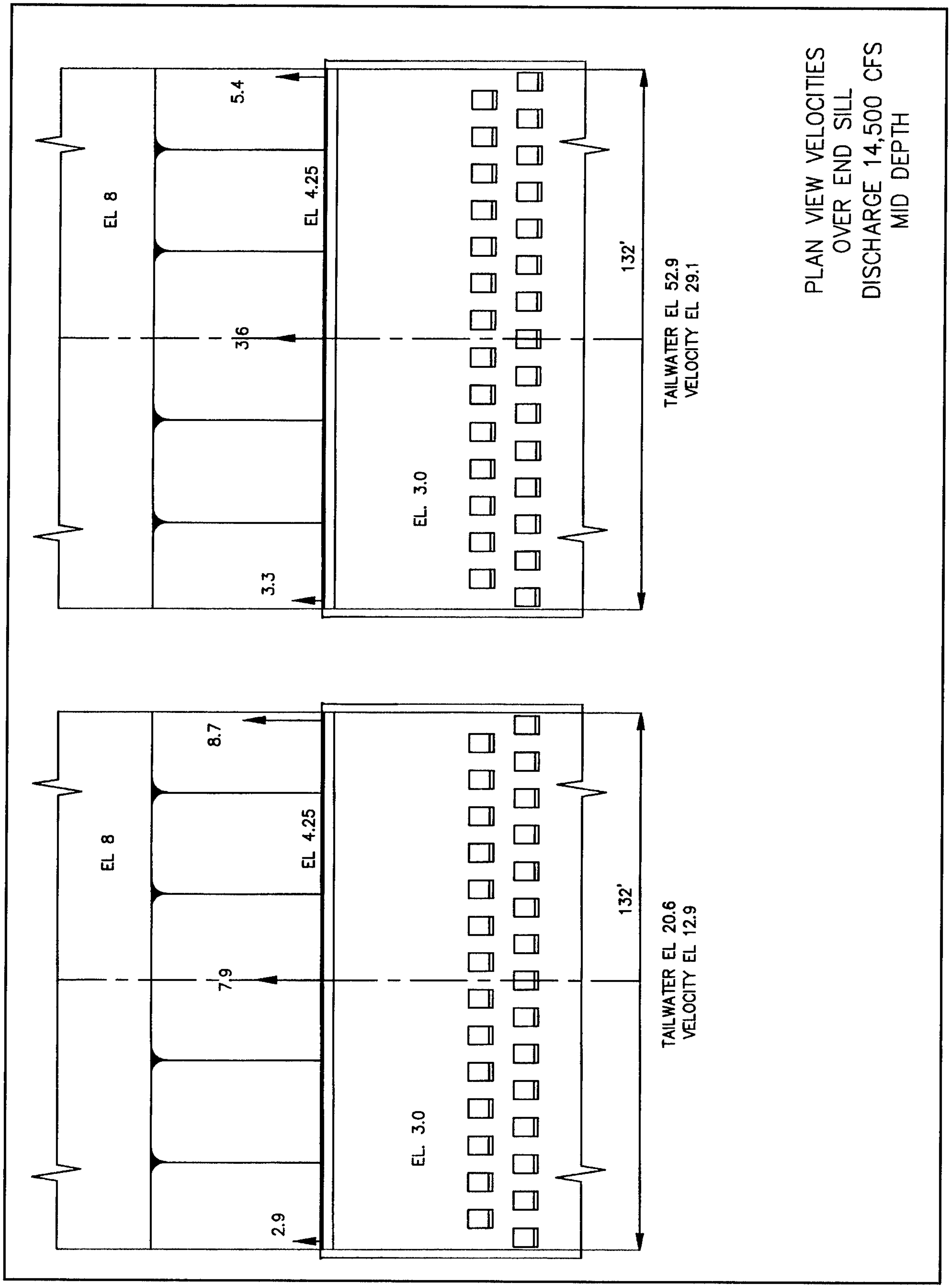


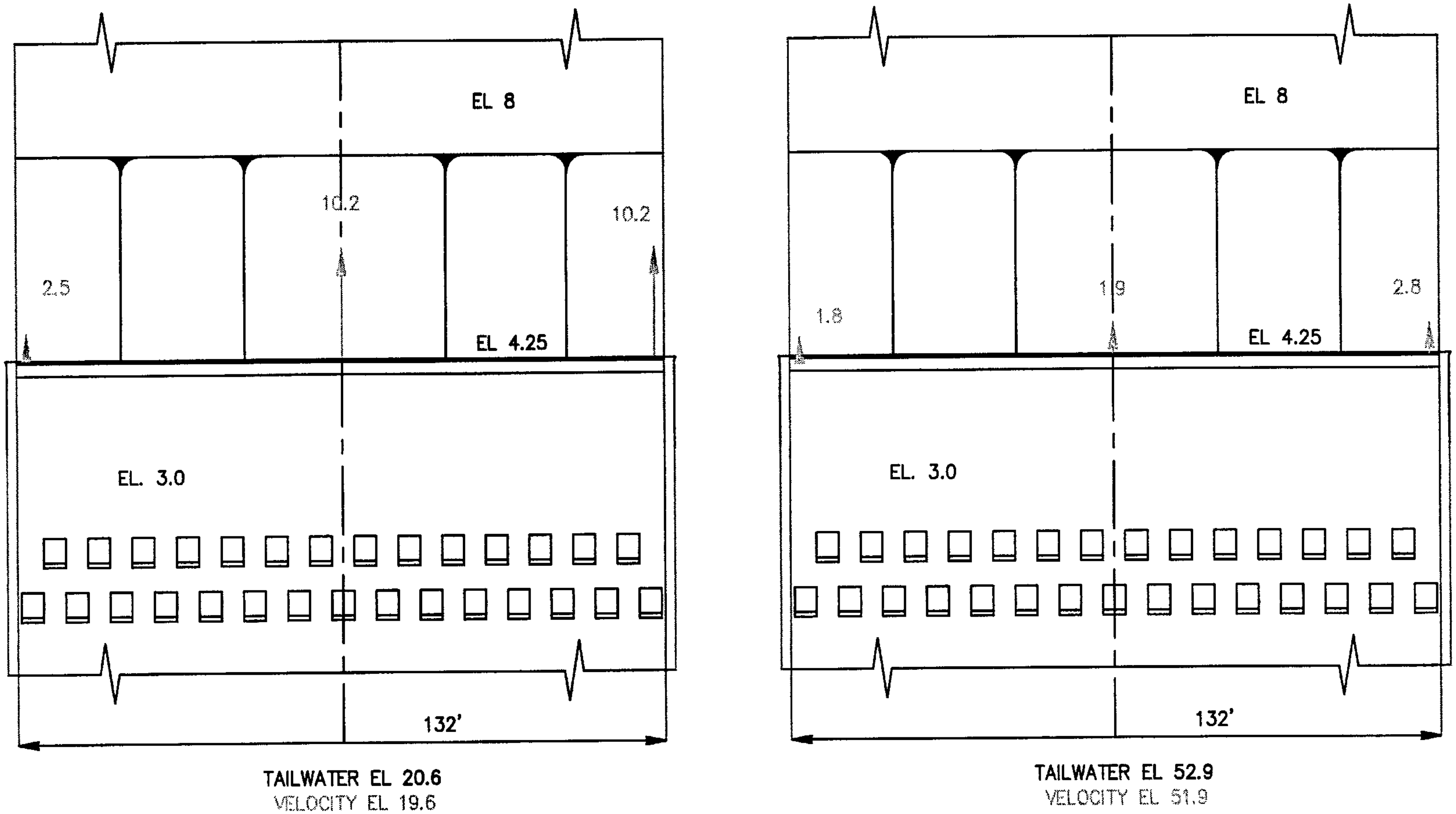
PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 7,890 CFS
NEAR SURFACE





PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 14,500 CFS
1 FT ABOVE END SILL


PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 14,500 CFS
MID DEPTH
EL 8
EL 4.25
5.4
3.6
3.3
EL. 3.0
132'
TAILWATER EL 52.9
VELOCITY EL 29.1
EL 8
EL 4.25
8.7
7.9
2.9
EL. 3.0
132'
TAILWATER EL 20.6
VELOCITY EL 12.9



PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 14,500 CFS
NEAR SURFACE

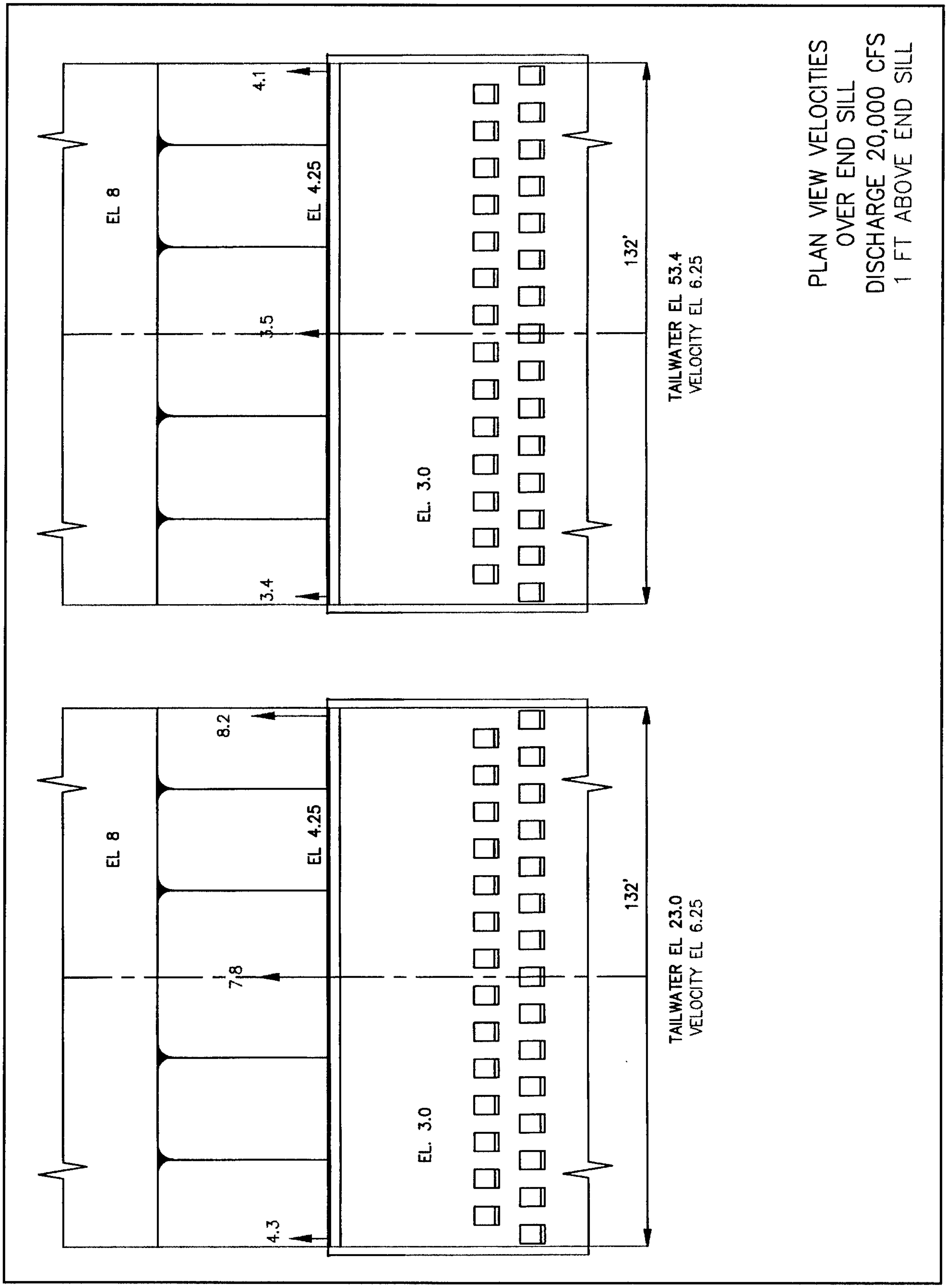
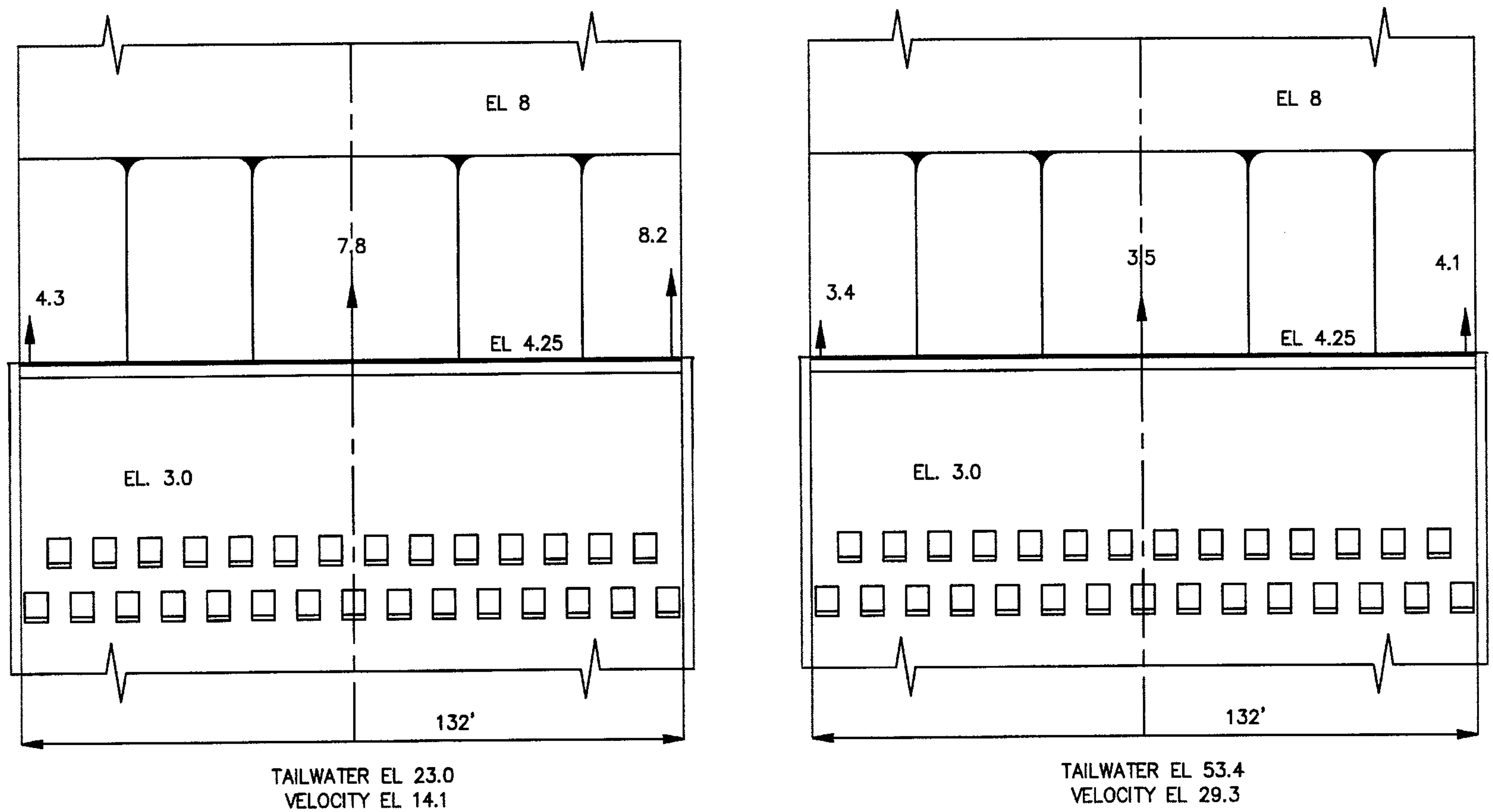

PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 20,000 CFS
1 FT ABOVE END SILL
EL 8
EL 4.25
EL. 3.0
132'
4.1
3.5
3.4
TAILWATER EL 53.4
VELOCITY EL 6.25
EL 8
EL 4.25
EL. 3.0
132'
8.2
7.8
4.3
TAILWATER EL 23.0
VELOCITY EL 6.25

Plate 28



PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 20,000 CFS
MID DEPTH

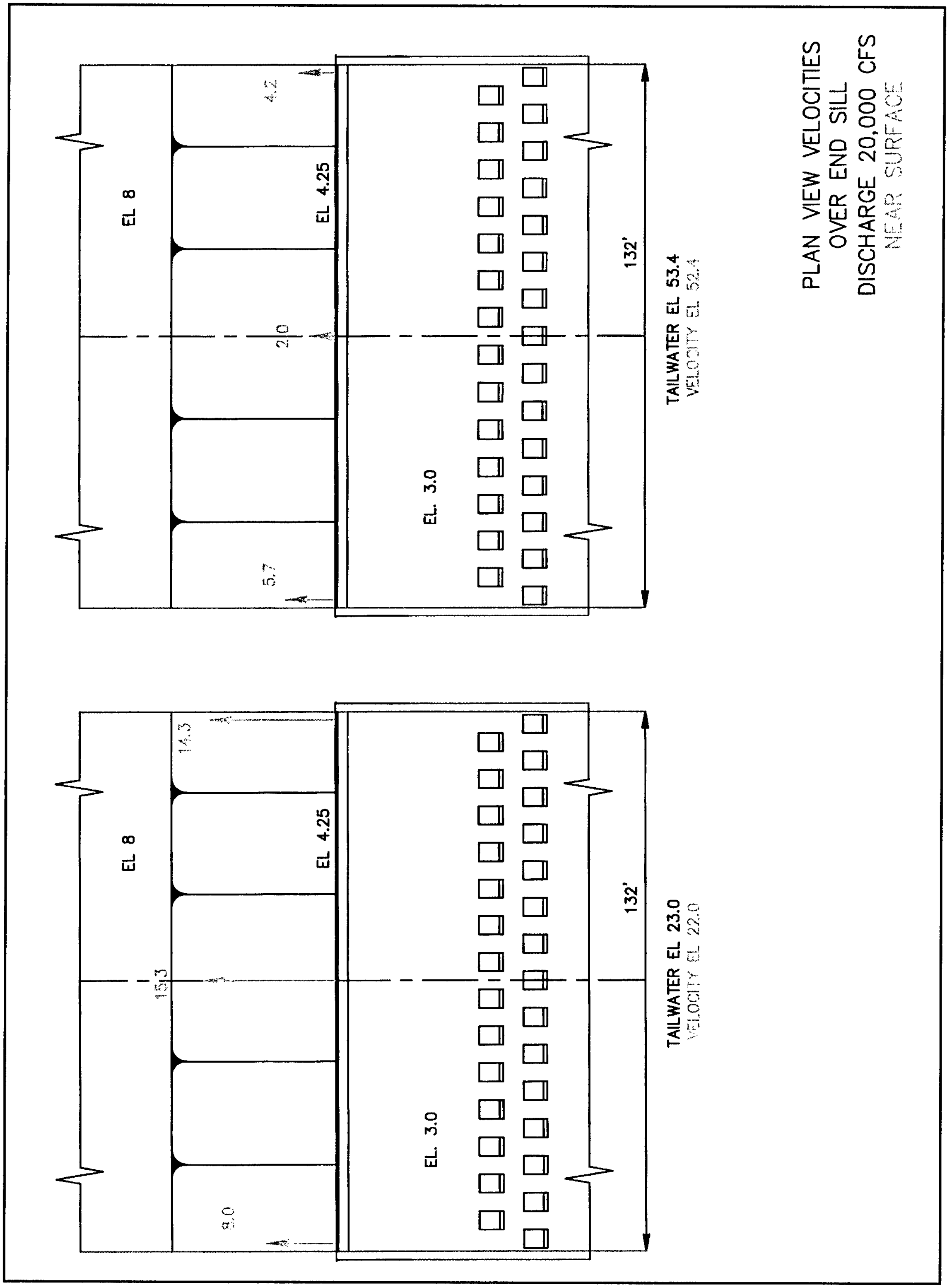
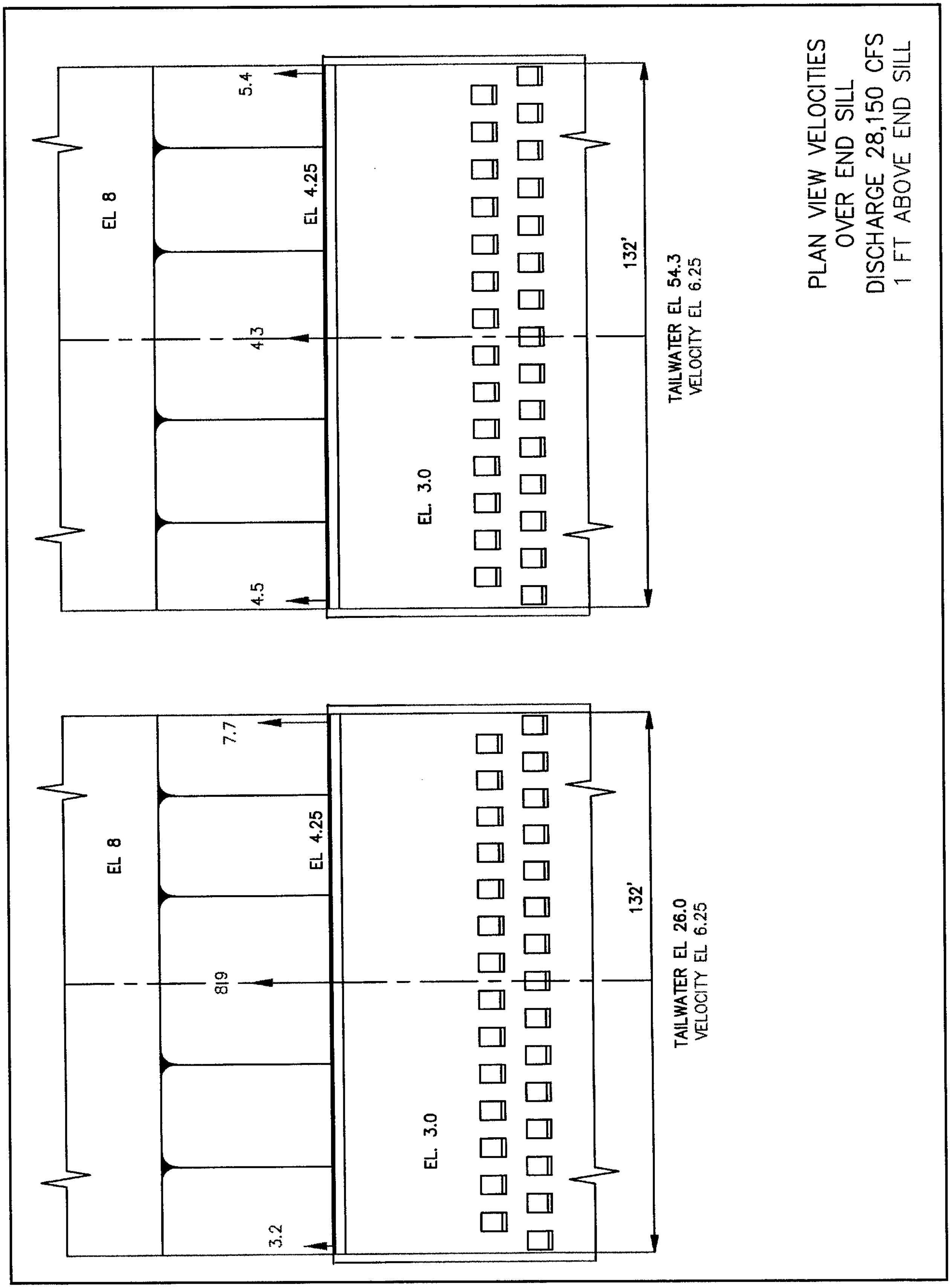

PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 20,000 CFS
NEAR SURFACE
EL 8
EL 4.25
EL. 3.0
132'
TAILWATER EL 53.4
VELOCITY EL 52.4
4.2
2.0
5.7
TAILWATER EL 23.0
VELOCITY EL 22.0
14.3
15.3
9.0

Plate 30



PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 28,150 CFS
1 FT ABOVE END SILL

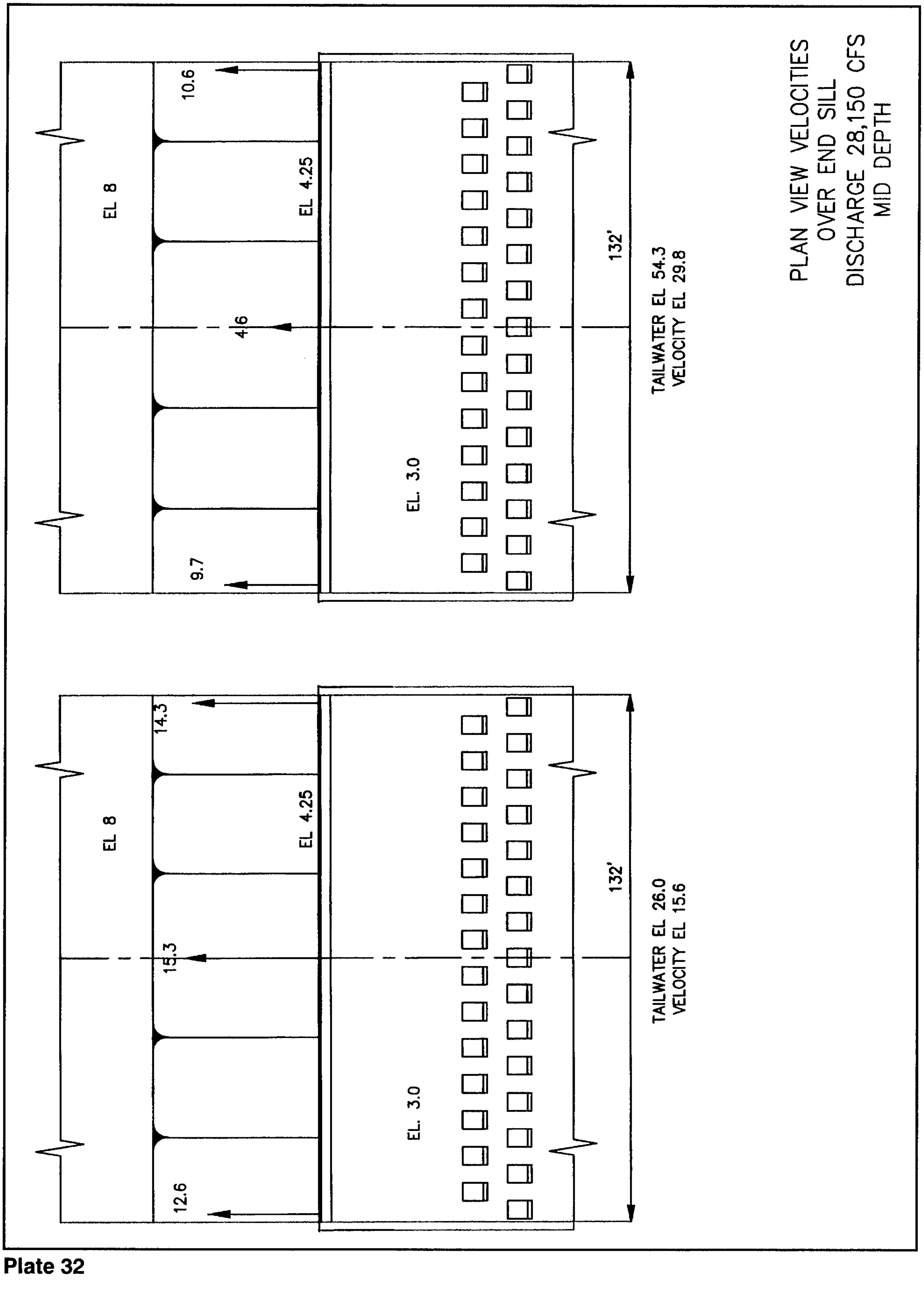
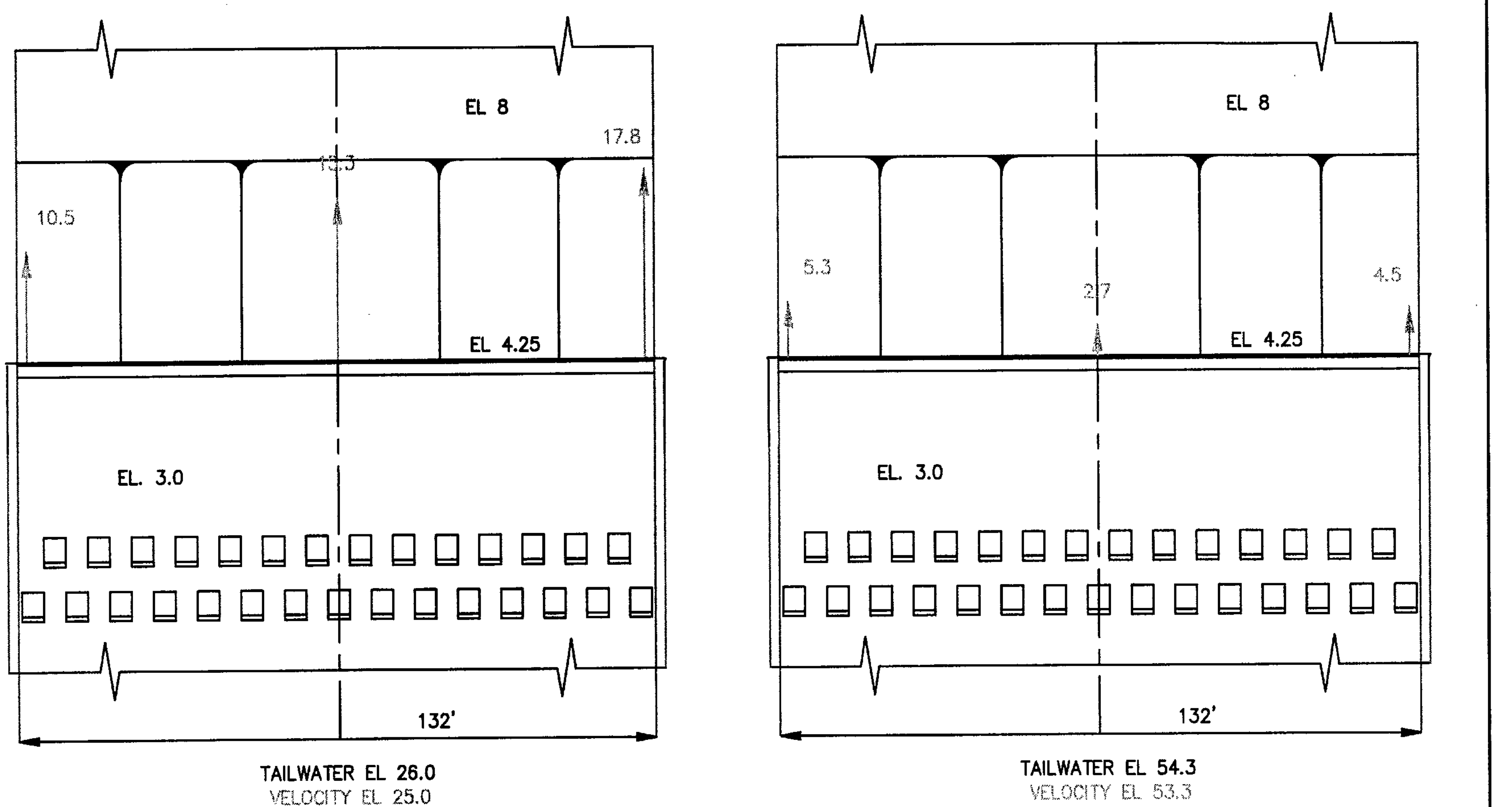
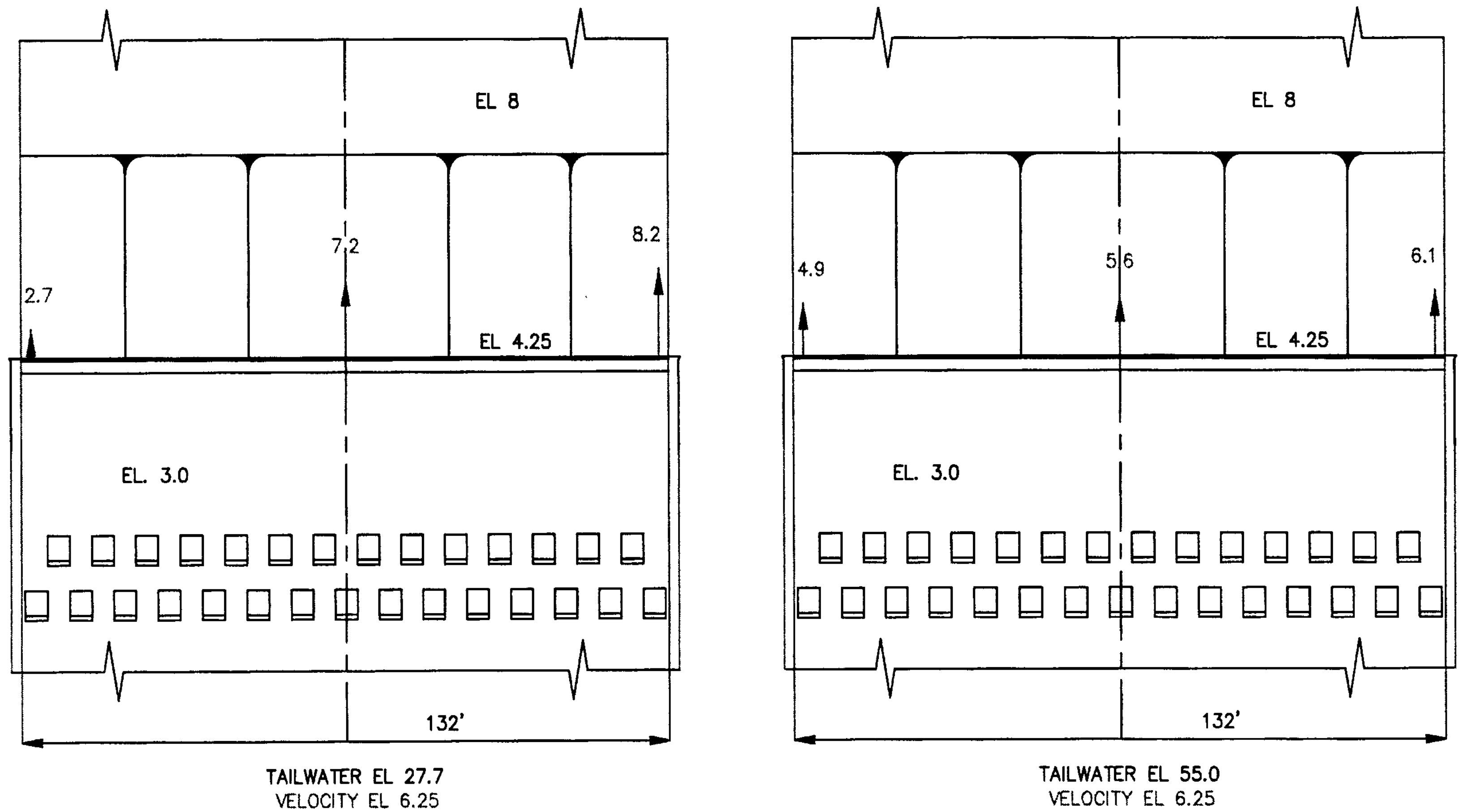

PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 28,150 CFS
MID DEPTH
EL 8
EL 4.25
10.6
4.6
9.7
EL. 3.0
132'
TAILWATER EL 54.3
VELOCITY EL 29.8
EL 8
EL 4.25
14.3
15.3
12.6
EL. 3.0
132'
TAILWATER EL 26.0
VELOCITY EL 15.6

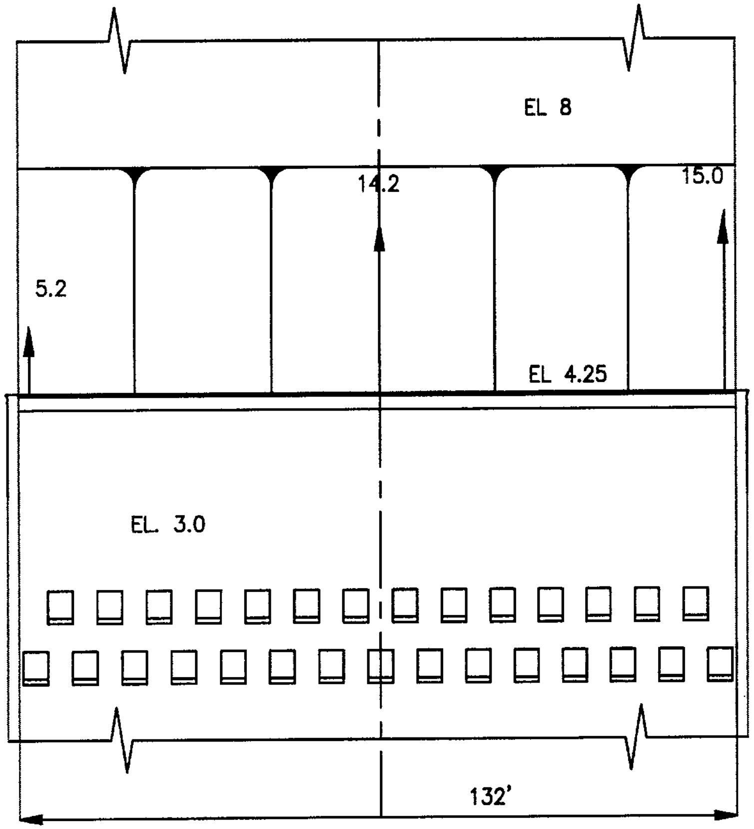
Plate 32



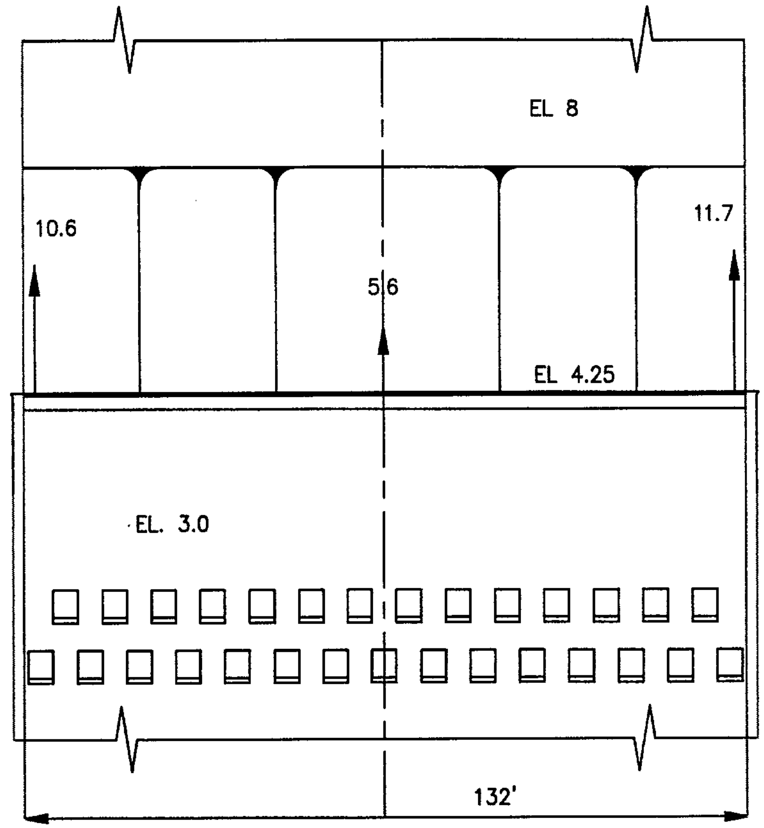
PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 28,150 CFS
NEAR SURFACE



PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 33,400 CFS
1 FT ABOVE END SILL

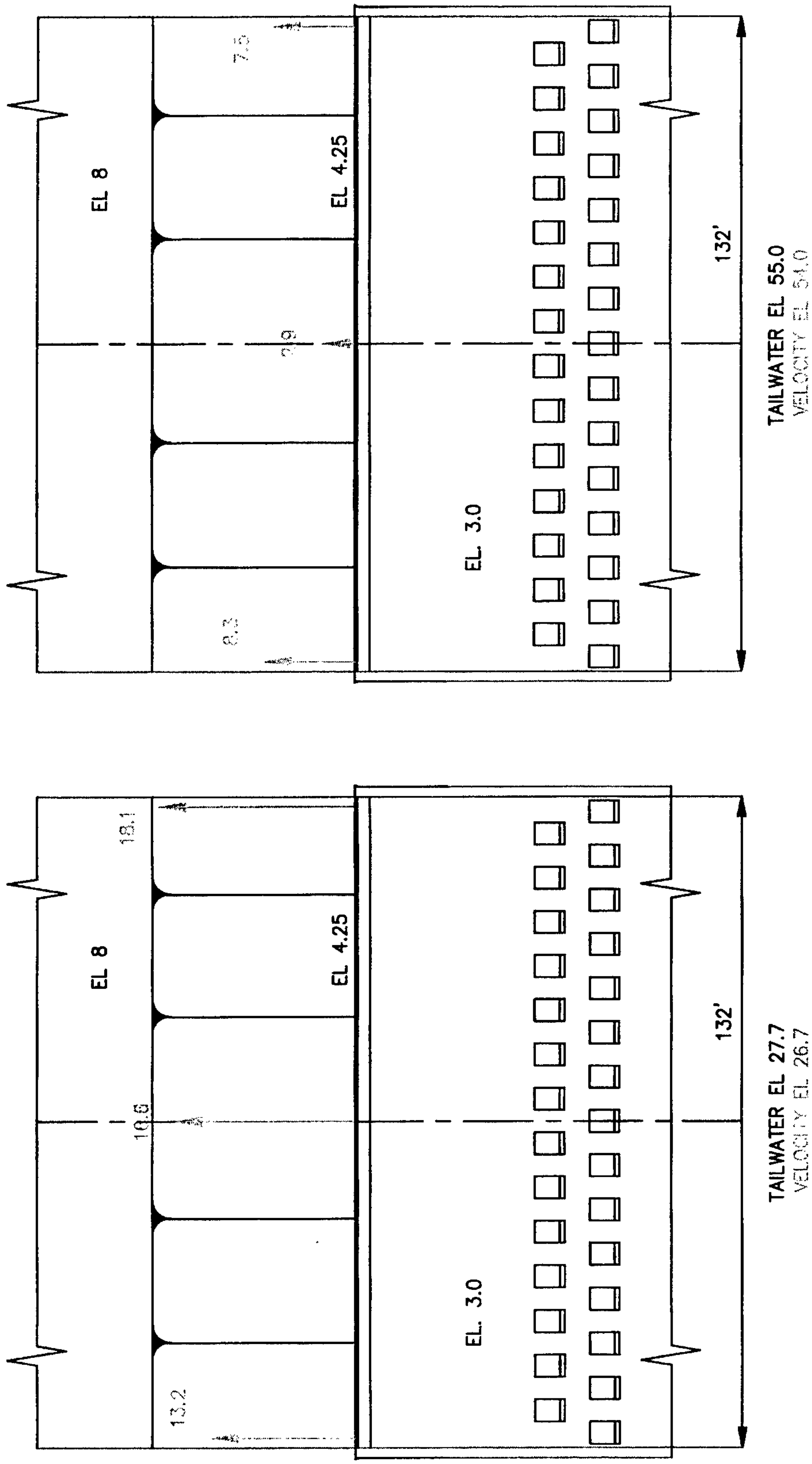


TAILWATER EL 27.7
VELOCITY EL 16.5

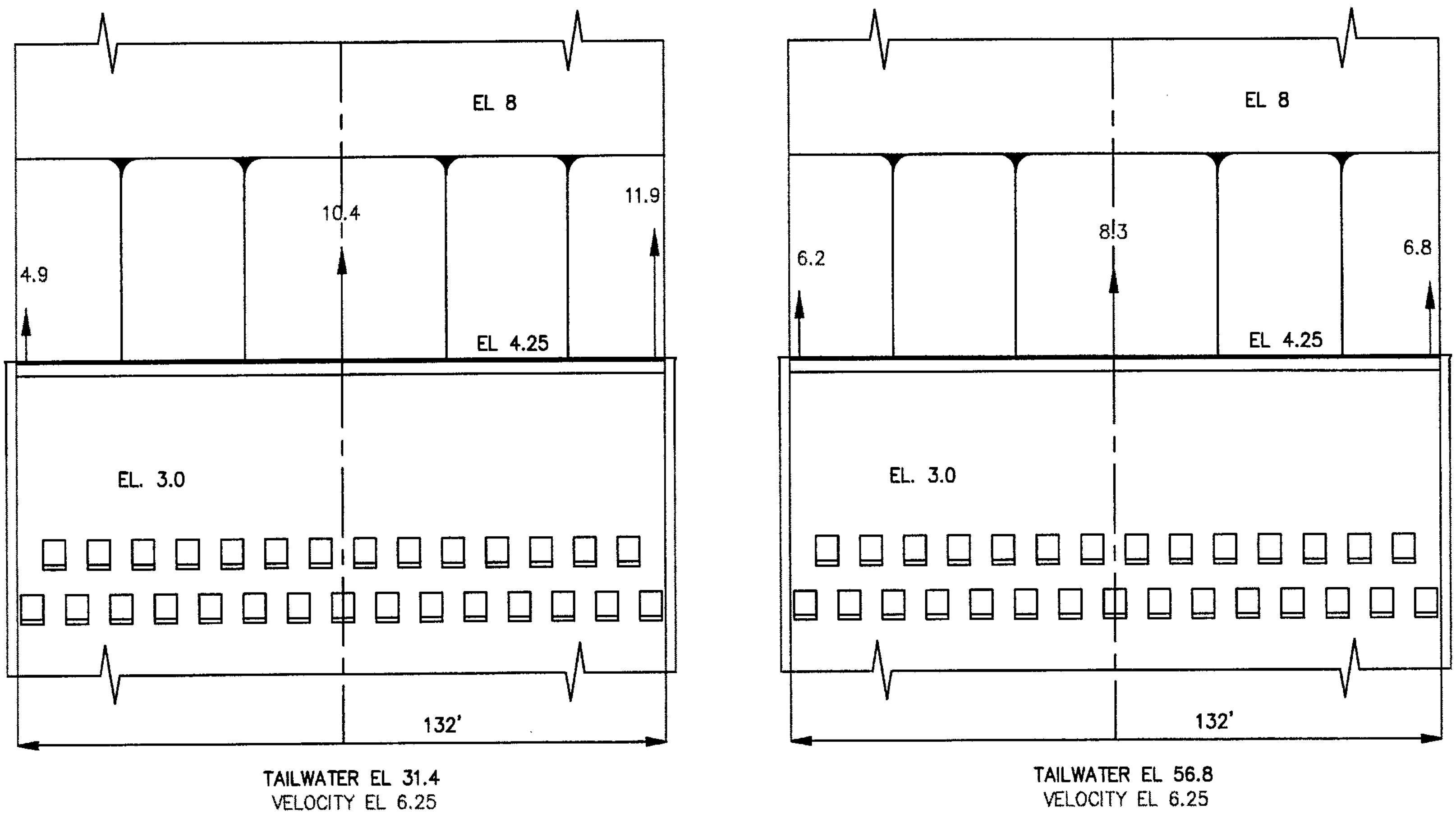


TAILWATER EL 55.0
VELOCITY EL 30.1

PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 33,400 CFS
MID DEPTH



PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 33,400 CFS
NEAR SURFACE



PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 46,500 CFS
1 FT ABOVE END SILL

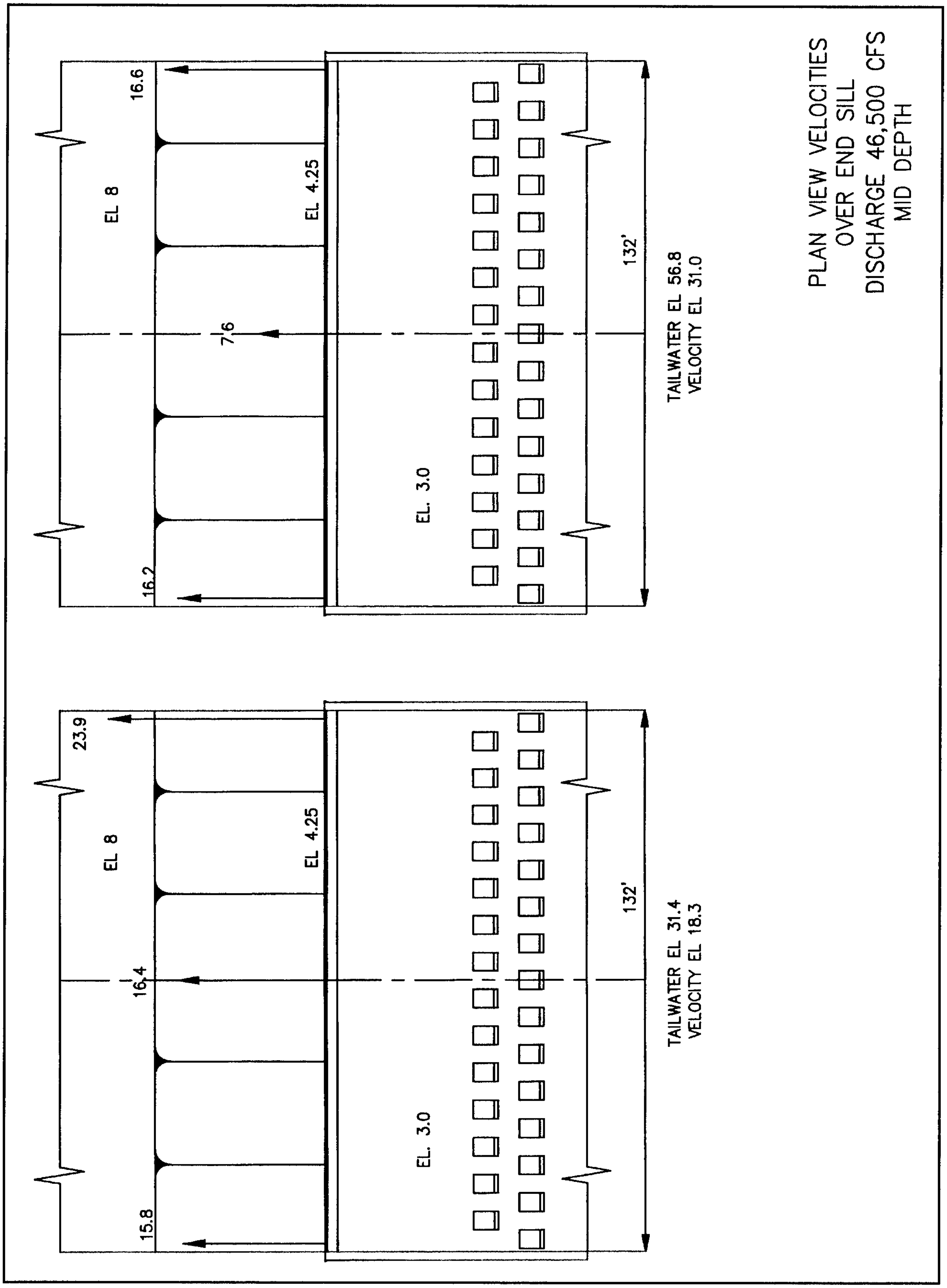
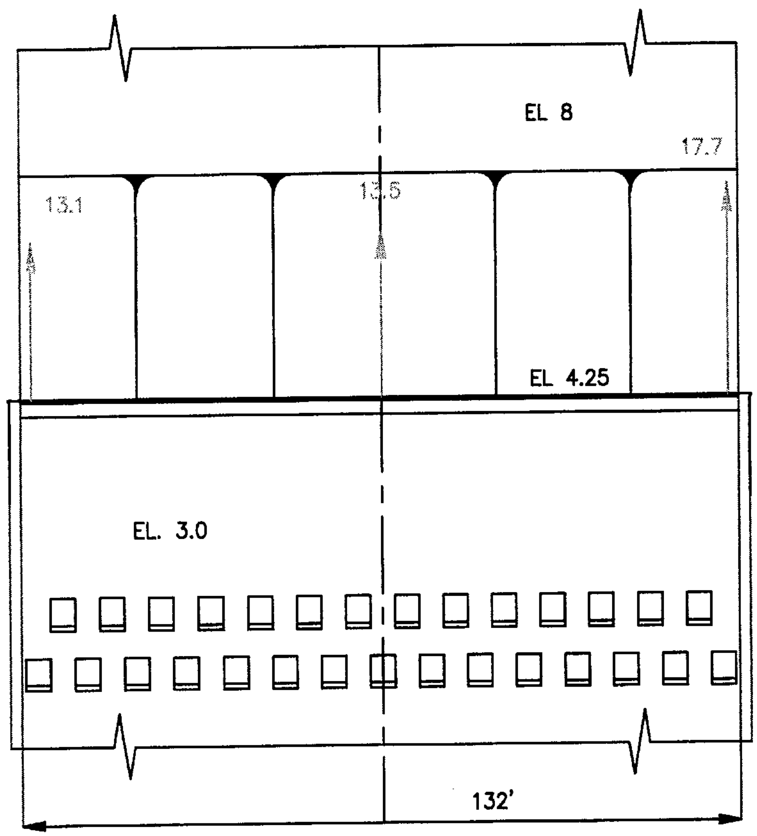
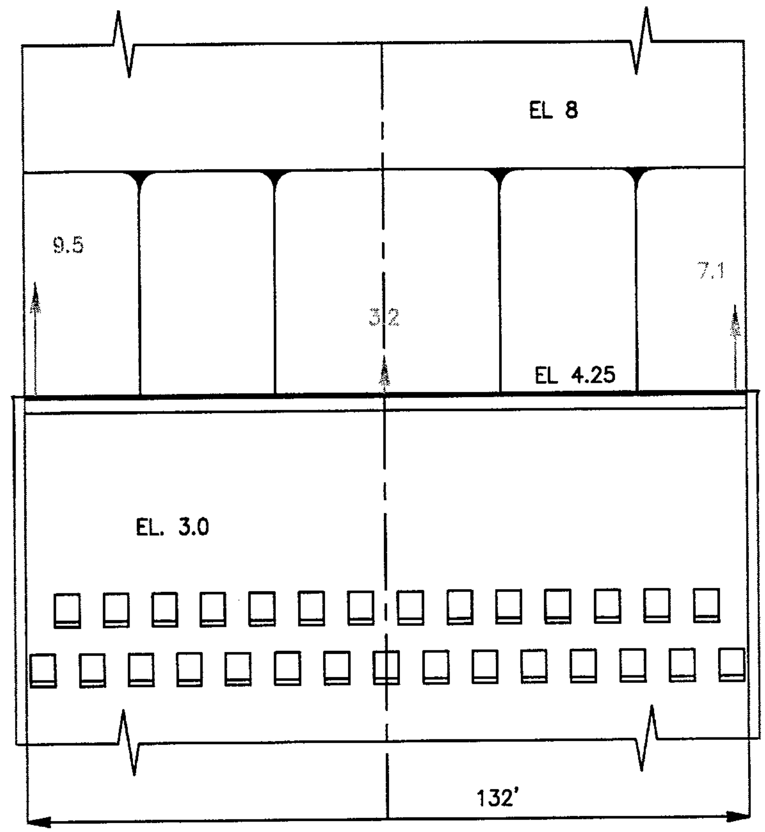

PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 46,500 CFS
MID DEPTH
EL 8
EL 4.25
EL. 3.0
132'
16.6
7.6
16.2
TAILWATER EL 56.8
VELOCITY EL 31.0
EL 8
EL 4.25
EL. 3.0
132'
23.9
16.4
15.8
TAILWATER EL 31.4
VELOCITY EL 18.3

Plate 38

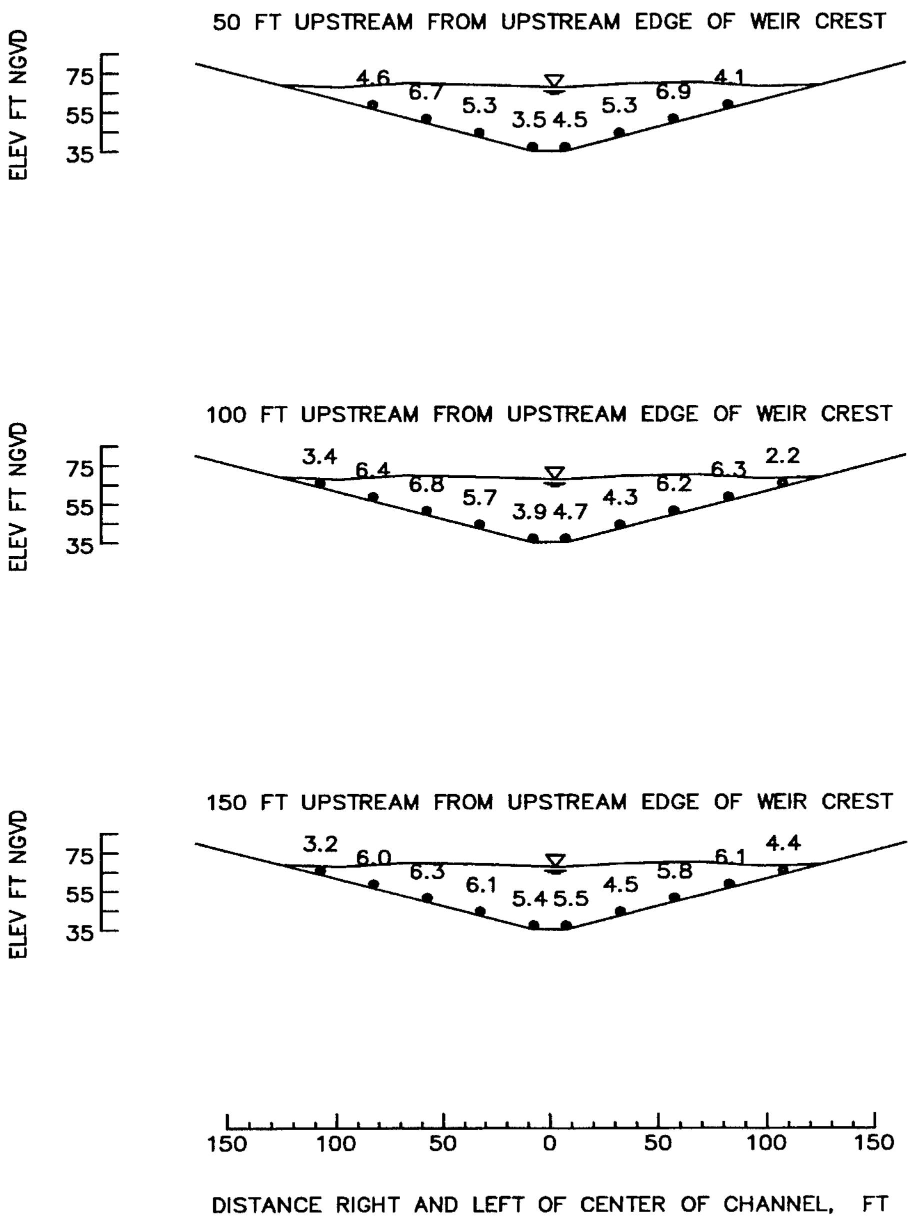


TAILWATER EL 31.4
VELOCITY EL 30.4

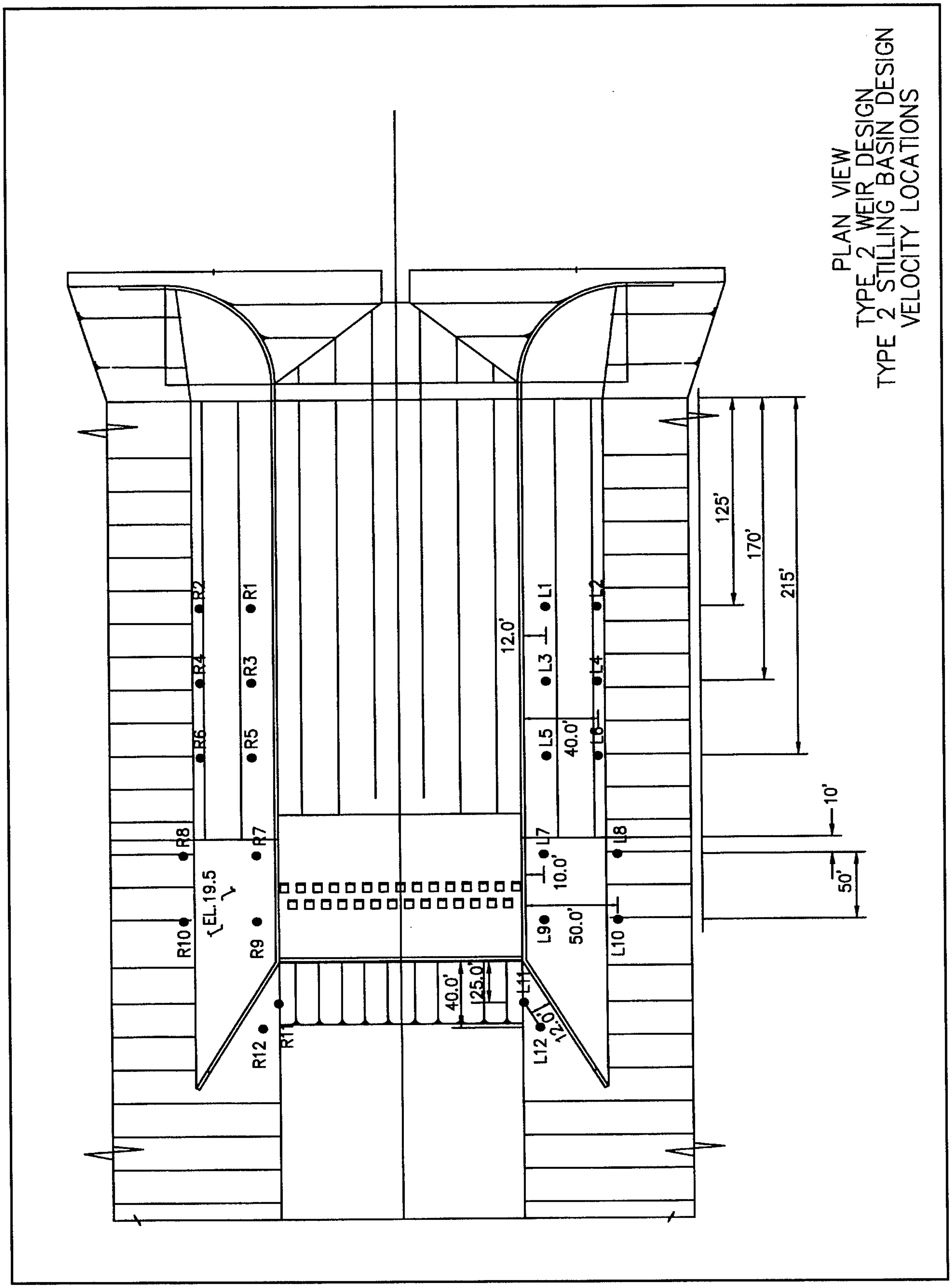


TAILWATER EL 56.8
VELOCITY EL 55.8

PLAN VIEW VELOCITIES
OVER END SILL
DISCHARGE 46,500 CFS
NEAR SURFACE



VELOCITIES IN INFLOW CHANNEL
1V ON 3.5H SIDE SLOPES
DISCHARGE 28,150 CFS


PLAN VIEW
TYPE 2 WEIR DESIGN
TYPE 2 STILLING BASIN DESIGN
VELOCITY LOCATIONS
125'
170'
215'
10'
50'
12.0'
40.0'
10.0'
50.0'
25.0'
12.0'
EL.19.5
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
June 2000

2. REPORT TYPE
Final Report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Comite River Diversion Project—Diversion Channel Stage Control Structure (Lilly Bayou Structure), Comite River, LA

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
John E. Hite, Jr., Joe Myrick

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Engineer Research and
Development Center
Coastal and Hydraulics Laboratory
3909 Halls Ferry Road
Vicksburg, MS 39180-6199;

8. PERFORMING ORGANIZATION REPORT NUMBER

ERDC/CHL TR-00-11

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Engineer District, New Orleans
7400 Leake Avenue
New Orleans, LA 70118

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The proposed Comite River Diversion Project was designed to lower flood stages along the Comite and Amite Rivers by diverting Comite River flood flows to the Mississippi River. Previous hydraulic models were used to help develop the diversion plan. The hydraulic requirements for the diversion channel stage control structure (also referred to as the Lilly Bayou structure) that were developed in the previous study changed, and another hydraulic model was necessary to verify the performance of the new design.

A satisfactory design for the Lilly Bayou structure was developed using a 1:36-scale hydraulic model. The model reproduced 112.78 m (370 ft) of the approach channel, the weir crest, spillway, and stilling basin, and approximately 243.84 m (800 ft) of the outflow channel. Modifications which consisted of lowering the weir crest, lowering the stilling basin floor, and changing the side slopes in the approach channel from 1V on 3H to 1V on 3.5H were made to achieve the desired hydraulic performance.

15. SUBJECT TERMS
Comite River, Louisiana; Rating curves; Weirs; Hydraulic model; Stilling basin

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
UNCLASSIFIED		UNCLASSIFIED		78	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18